well as excess visibility amplitude for projected baseline lengths much greater than the diffractive scale. We also find that most scattered-broadened images are significantly elliptical with orientations which may be related to the large-scale magnetic field orientation in the Cygnus superbubble.

46.14

Extreme Scattering Events

T. Joseph, W. Lazio (NRC, NRL), A. L. Fey (USNO), B. Dennison (VA Tech)

Extreme scattering events (ESEs) are a class of dramatic changes in the flux density of radio sources. They are marked by a decrease ($\approx$50%) in the flux density near 1 GHz for several weeks to months, bracketed by substantial increases. ESEs are thought to be due to refractive scattering by ionized structures in the Galactic interstellar medium—structures potentially associated with sites of interstellar turbulence.

We are conducting a three-pronged investigation of ESEs: (1) Improved modeling of the lensing structures and ray tracing have been used to make quantitative comparisons with observed light curves. (2) VLBI imaging of the source 1741 − 038 during an ESE. (3) A wavelet analysis of Green Bank Interferometer light curves in order to assess, in a systematic manner, the probability that a source will undergo an ESE.

We use geometrical optics to study the refraction of a distant background radio source by a plasma lens (Clegg *et al.* 1998, *ApJ,* **496,253**). We find general agreement between modelled and observed light curves at 2.25 GHz, but poor agreement at 8.1 GHz. The discrepancies may result from some combination of lens substructure, anisotropic lens shapes, lenses which only graze the sources, or unresolved substructure within the sources. A typical lens is 0.1 AU in diameter with an electron density of 10^4 cm^{-3}. A lens may cause angular position wander of 0.1–100 mas at 2.25 GHz.

As 1741 − 038 underwent its ESE, its structure remained essentially unchanged. There is little evidence for additional angular broadening during the ESE nor is there any evidence for lensing-induced substructure in the source, such as might be caused by strong refraction or substructure within the lens. We detect no evidence of angular wander, though we have limited ability to detect angular wandering and our models predict that the amount of angular wander was only 0.4 mas at 2.2 GHz.

We present wavelet scalograms constructed from GBI light curves. We show the scalograms for various sources and illustrate how these scalograms can be used to identify an ESE.

46.15

On the Theory of Pulse Propagation and Two-frequency Field Statistics in Irregular Interstellar Plasmas

H. C. Lambert (UC San Diego)

Two-frequency second moments and pulse profiles are computed for plane and spherical waves both propagating in an extended plasma and incident on a thin plasma phase screen located between the source and the observer. The various models considered for the electron-density wavenumber-spectrum are the simple power-law model, the power-law model with an inner scale, the "$\beta = 4$ model," and the square-law structure function model. The power-law model with spectral exponent $\beta = 11/3$ corresponds to the Kolmogorov turbulence spectrum. The $\beta = 4$ model suggests the random distribution in location and orientation of discrete objects across the line of sight. An outer scale is included in the $\beta = 4$ model to account for the average size of the objects. The diffractive decorrelation bandwidth, $\Delta\nu_d$, obtained from the square of the magnitude of the two-frequency second moment, is related to the scattering broadening time, Δt_d, via the Fourier uncertainty relation: $2\pi\Delta\nu_d\Delta t_d = C_1$. Numerical values for the constant C_1 are computed for the aforementioned geometries and spectral models of the scattering medium. The theoretical pulse profiles reveal similar scattering tails regardless of the distribution of scattering material along the line of sight. Hence measurements of the scattering tails of pulsars may be used to constrain the various spectral models of the galactic electron density fluctuations, independent of the scattering geometry.

46.16

VLBA imaging of small-scale structure in Galactic HI

M.D. Faison (U. Wisconsin, Madison/NRAO), W. M. Goss and P. J. Diamond (NRAO-Socorro)

We have used the Very Long Baseline Array (VLBA) in addition to the phased Very Large Array (VLA) with angular resolution 10-20 milliarcseconds (mas) to image the Galactic HI in absorption in the direction of three bright extragalactic objects 3C138, CJ1 2255+416, and CJ1 0404+768. The angular resolution of these images is 20 milliarcseconds in the case of 3C138 and 10 milliarcseconds for 2255+416 and 0404+768. HI optical depth variations up to a factor of two are seen in the directions of 3C138 and 2255+416 on angular scales down to the resolution of the images. 0404 +768 shows much smaller variations of only about 15% over 10 milliarcseconds, and is consistent within the errors of showing no significant optical depth variations. The small-scale opacity structure seen towards 3C138 and 2255+416 could be due to density variations, spin temperature variations, velocity turbulence in the atomic gas, or a combination of these effects. If the variations are due to density fluctuations, this implies high density structures of order 10^6 cm^{-3} in the cold neutral medium on physical scales of 10 AU or less. This implies thermal pressures in the small-scale structure several orders of magnitude greater than the that observed in the general diffuse ISM. However, if the large column density variations are due to elongated structures such as filaments or sheets seen edge on, the densities (and pressures) can be reduced by envoking an elongation factor along the line of sight.

Session 47: The Shapley Visiting Lectureship Program
Topical, Oral Session, 2:30-6:00pm
Friars

47.01

Shapley, Introduction

A. G. Davis Philip (ISO and Union College)

Under the Shapley Visiting Lectureships Program astronomers make two-day visits to colleges and universities in the United States and Canada (and next year in Mexico) to promote astronomy by giving a set of talks and by interactions with students, staff and administration. The main talk is the Shapley Lecture, usually given in the evening and open to all interested people in the area. The lecturer can talk to a class or give a colloquium or talk at a local high school. At present there are about 85 lecturers in the program and we make about 50 visits each year. Most of the visits are made by car but each year there are some requests from institutions that are too remote so in these cases we fly lecturers in to make the visit. The program is supported by the fees paid by the institutions and by interest from the Shapley Endowment Fund. At this topical meeting there will be discussions by some of the early people before there was a Shapley Visiting Lectureships Program, by four of the previous and present Shapley Directors, by a visitor who has made 50 Shapley visits, a Shapley Lecturer at NSF and by representatives from two of the frequently visited institutions.

47.02

Harlow Shapley and the Harvard Graduate School

Dorrit Hoffleit (Yale University Observatory)

Shapley was appointed director of the Harvard College Observatory in 1921 and continued as director until 1952. Activities during these years and the interaction of the author with Shapley and Bart Bok are described.

47.03

The AAS Committee on Education: The First Decade

G. Reaves (Univ. of Southern California)

Activities from about 1955 to 1965 included writing an up-to-date career brochure, the administration of the Program of Visiting Professors of Astronomy (now the Shapley Visiting Lectureships Program), the institution of educational films promoting astronomy as a career, the organization of a Conference on Graduate Education in Astronomy and a discussion questioning the need for accreditation of degree-granting departments of astronomy.

The committee meetings also afforded the opportunity for informal discussions for the improvement of teaching, from kindergarten through graduate school.

47.04

The Shapley Program From its Beginnings to 1985

Harry Shipman (U. of Delaware)

The Shapley Program began as an NSF-funded visiting professors program in the 1980s. The American Astronomical Society kept it going by raising an endowment fund to support it, largely under the leadership of Bart Bok and Peter Van de Kamp and with significant help from the Shapley family. I will review the operation of the program during this time, with particular emphasis on the 1979 - 1985 period where I was very closely involved. Evaluations of the program revealed that it has contributed very substantially to the public appreciation of astronomy, particularly in places which are remote from the planetariums and science museums located in major urban centers. There are indications that it contributed to the decisions of many universities to add astronomers to their faculty.

47.05

The Shapley Program 1985 - 1990: The Virginia Years

C. R. Tolbert (University of Virginia)

The Shapley Program moved to the University of Virginia from the University of Delaware in the summer of 1985. Prior to moving to Charlottesville the program had been run by Harry Shipman. 1985 - 1986 was the year of Comet Halley, and it was also the year that the program reached its peak of visits made by the astronomical community. We scheduled 135 visits that year. Luckily, I was new on the job and didn't realize the effort that would be involved in coordinating that many visiting astronomers. One way or the other we got through the "big" year and, after consultation with the Council, established a maximum number of visits to be scheduled per year at 80. We maintained that number every year through the Virginia period.

It was during this time that the office purchased its first computer and computerized the mailing list. We sent brochures to some 2,000 plus colleges and junior colleges throughout the US, Canada and Mexico. (Regrettably, we never received a request form a Mexican school.) The fee charged to the school for each visit was $75 per visit in the beginning and rose to $200 per school by the end of the period. The rest of the costs of the program were borne by the Shapley Endowment Fund and the AAS Education Office. We waived the fee from a number of schools on request.

In addition to being a Shapley Lecturer myself, I had the great pleasure during this period of receiving the many compliments about the program. There is no question that the Shapley Visiting Lectureships Program provides an excellent service to small colleges in both the US and Canada. Based on the reports of our success, the American Physical Society reinstituted their lecture program as did the American Optical Society.

47.06

The Shapley Program 1991 - 1993

M. K. Hemenway (University of Texas at Austin)

From September, 1991 through June, 1994 the Harlow Shapley Visiting Lectureships Program was administered from the University of Texas at Austin. Seventy-five visits [selected from 87 applications] were made in the 1991 - 92 program. Sixty-four visits [selected from 91 applications] were made in 1992 - 93. Recognizing that the Shapley Endowment Fund was not being increased at a rate which allowed for inflation, new cost-cutting measures went into effect for the 1993 - 94 program. These resulted in a cut-back in both solicitation of colleges and assignment of lecturers; twenty-seven visits [selected from 42 requests] were scheduled with the funding allocated by the AAS Council for twenty visits. Several efforts were made between 1991 and 1994 to locate additional outside funding for the Program. The program director had several discussions with the National Science Foundation concerning the efficacy of the program in provided advice concerning astronomy instruction and a higher profile for astronomers at two year colleges. Another tactic was to solicit donations from the AAS membership; the request for the Shapley Program was one of the first items listed on membership dues statements as a possible separate donation item. The first donation request went out with the annual membership mailing in late 1993.

47.07

The Shapley Program 1994 - 1998

A. G. Davis Philip (ISO and Union College)

In the last four years a number of changes have been made in the operation of the Shapley Program. One of the first was to encourage lecturers to make visits by car rather than by air. Driving trips end up costing an amount about equal to the amount contributed by institutions. More remote locations are still done by air. All the Shapley data that I inherited from Mary Kay Hemenway have been placed in a database so now it is easy to find out who went where and when, which universities have had visits, how many visits are made each year, how many visits have been made by each lecturer. We have started awarding certificates to lecturers who have made 15 or more, or 25 or more visits. The AAS Council has agreed to place interest in excess of 4% back into the Shapley Endowment Fund. This helps mitigate the effects of inflation over long periods of time. The Shapley Program is being extended to Mexico and in the 1998 - 99 academic year we hope to have a few Mexican visits. The papers at this meeting will be placed on the AAS web pages and will serve as a resource for those interested in finding out more about the Shapley Program.

47.08

Adventures on the Shapley Circuit

A. Heiser (Vanderbilt University)

From my first participation in the Visiting Professor's program more than thirty years ago to my most recent visit, as a Harlow Shapley Visiting Lecturer, I have been privileged to be able to assist AAS, (a) in their efforts to stimulate more interest in Astronomy by providing students and faculty members at small colleges with practical advice on careers, teaching programs and facilities, and (b) to presenting current astronomical ideas and concepts to local communities via the public talks. Virtually all of my visits have been enjoyable, satisfying and rewarding, with some even accompanied by opportunities to see places of historical and scenic interest. There have also been a small number of occasions, fortunately, when "mis-adventures" and frustrations occurred during the visits. Finally, I will try to present some impressions of my visits as to their being successful to the overall aims of our Visiting Programs.

47.09

Leveraging the Shapley Lectures

S. Howard (Astronomy Division, NSF)

The Shapley Lectureships are both an honor and a privilege. The program has long provided the non-specialist a rare glimpse of the latest result of astronomical investigations. Shapley Lecturers carry the banner for the most interesting of all the sciences. They share the beauty and strength of astronomy by representing the discipline to non-specialists.

It is important that we contribute what we can to this program. One might benefit from the frequent travel of most astronomers. Most research trips are now covered by grant money, by university money, and by Government money. Leverage this travel. For example, many meetings are held near places with small colleges. Consider sending a Shapley brochure to the science departments before your trip. Such trips may often be used to elicit a Shapley visit. Advertise the program. When we talk about astronomy to others we help all of us to keep this science alive. I will share the results of my Shapley Visits made in the last four years while traveling for NASA and NSF.

47.10

How Shapley Lectures have Enriched a Small University in the Heart of Michigan

L. Reed (Saginaw Valley State University)

Saginaw Valley State University (SVSU), is tucked in the industrial heartland of central Michigan. Our students can best be described as non-traditional in the sense that many are employed full - or part-time while working to upgrade or complete a degree. Our Physics Department is a small but active member of the College of Science, Engineering and Technology. Many Shapley lecturers have visited us over the years and each has inspired our students, faculty and community to think about the universe in a new and exciting way. I will share some of the feed back we have received about the program and emphasize its continuing importance to smaller institutions like SVSU.

47.11

A Partnership in Mississippi for Promoting Astronomy to Diverse Sectors of the Public

K. Ghosh, Mehri Fadavi, Hai-Shou Yang (Jackson State U.)

In Mississippi the Harlow Shapley Visiting Lectureships are hosted by a growing consortium which currently has seven members; French Camp Academy and the Rainwater Observatory, a private high school and the state's largest observatory; Holmes Community College, a multicampus community college; Jackson Astronomical Association; Jackson State University, a historically black college or university (HBCU) and state comprehensive institution of higher learning with an urban mission; the Russell C. Davis Planetarium and the Davis Planetarium Foundation since renamed Mississippi Science Network, Inc., serving the whole state with a ''Science is for Everyone'' mission; St. Andrews Episcopal School, an urban high school; Tougaloo College, a private urban HCBU; and Mississippi Science Partnership. The Partnership, founded in 1990 as a novel alliance of state institutions of higher learning, a state school system and a major private corporation, with ''the vision of improving the teaching and learning of mathematics and science for years to come in the state of Mississippi,'' leads the consortium and coordinates the Lectureships with the partners. The lecturer typically spends two days, gives public, free lectures at the college and school campuses and at the Planetarium, and holds formal and informal discussions with faculty, staff, students, amateur and professional astronomers in the region, and interested members of the public. The visit catalyzes improvements in astronomy education and research at the institutions. The Lectureships have also been an occasion for an informal meeting of the consortium where the members share their common joy and experiences in astronomy and its education and research.

98/06/10
Wednesday

Session 48: Workshop on the Future of Antarctic Astrophysics - I
Topical, Oral Session, 8:30-10:00am, 10:45am-12:30pm
Presidio

48.01

Antarctic, Introduction

John E. Carlstrom (U. Chicago)

The purpose of this all day session is to educate the astronomical community about the Antarctic site and the unique potential of Antarctica for astrophysics, and to involve the community in the planning of future observing facilities to be sited at the South Pole.

The conditions at the South Pole offer unique opportunities for Astrophysical research. The extremely cold, dry and highly stable atmosphere is exceptional for observations from the millimeter through the infrared. The nearly two mile thick polar ice cap can be used for high energy astrophysical particle detector telescopes, such as the Antarctic Muon and Neutrino Detector Array (AMANDA). Over the last several years, the Center for Astronomical Research in Antarctica (CARA) has carried out extensive site testing, successfully operated an observatory through the Austral winter, and conducted cutting edge astronomical observations. It is now time to plan for the future beyond CARA which, as a NSF-Science and Technology Center, ends in 2002.

The workshop begins with a plenary session which covers the history of Astrophysics at the Pole and summarizes the current research being conducted by the CARA and AMANDA collaborations. The speakers also will review the site characterization and the peculiarities of conducting research at the South Pole.

The day proceeds with parallel sessions of five science working groups. The chairs of the working groups will arrange speakers to address the potential of the Antarctic for conducting unique observations and experiments in their specific area of Astrophysics. The chairs then present a summary of their working group's findings at a plenary session. Talks on large instruments already being planned for the South Pole will also be presented during this session. The session concludes with a panel discussion on the scientific goals for the future of antarctic astrophysics.

Further information on the South Pole and on this Workshop can be found at http://astro.uchicago.edu/cara/aas/AASWorkshop.html.

48.02

The History of Astronomy in the US Antarctic Program

J. Lynch (NSF)

The talk will cover the history of Astronomy in the US Antarctic Program, especially at South Pole, from the International Geophysical Year in 1956-57 until the advent of the Center for Astrophysical Research in Antarctica (CARA) and the Antarctic Muon and Neutrino Detector Array (AMANDA) in the first few years of this decade. The achievements of the more recent observations will be discussed at this meeting by the people who actually did the research. I will relate the story from the personal perspective I have gained from being the Program Director for Antarctic Aeronomy and Astrophysics in NSFs Office of Polar Programs.

48.03

Neutrino Astronomy: First Light–Using The South Pole IceCap

R. M. Morse (Physics Dept., U. Wisconsin)

Astronomy is now able to investigate the photon spectrum from radio frequencies (the Cosmic Microwave Background Radiation–CMBR) to the highest-energy gamma rays using ground-based gamma-ray telescopes. However, because of the intergalactic CMBR and infra-red light (IR), space becomes increasing opaque to these high-energy photons as their energy increases. Neutrinos have a distinct advantage in this energy regime, for unlike photons of energies of 10^{13} eV and beyond, they are not absorbed by the intergalactic IR light and CMBR. Neutrinos can, in principle, reach us from the edge of the universe, whereas, if the sources of the high-energy cosmic rays were beyond the Virgo cluster, then the conventional window of exploration would be closed above 100 TeV. Thus, sources which may be responsible for the highest-energy cosmic rays may lie beyond the discovery radius of conventional astronomy.

48.04

The Python Cosmic Microwave Background Experiment

Mark Dragovan (Dept. of Astronomy and Astrophysics University of Chicago)

A summary of the five years of data from the Python Cosmic Microwave Background (CMB) experiment will be presented. Python was an experiment that detected and sampled the anisotropy in the CMB at sub-degree angular scales. In the first three years of observations, the system consisted of a .75 m telescope and a four pixel bolometric photometer operating at 90 GHz. In the last two years of observations, the photometer was replaced by a two pixel HEMT amplifier based radiometer operating at 40GHz. The same region of sky, uncontaminated by any known foregrounds, was observed at both frequencies. A joint analysis of the 40 and 90 GHz data sets confirms that the anisotropy observed is consistent with that expected from the CMB. In its last year of observations the Python experiment sampled approximately 600 deg^2 of sky. The large sky coverage, high signal to noise, and low contamination due to foregrounds, allows a reliable and robust determination of the power spectrum and higher order correlations of the CMB anisotropy.

48.05

AST/RO: Submillimeter Astronomy

Adair P. Lane (Harvard-Smithsonian Center for Astrophysics)

Submillimeter astronomy can only be pursued from extremely cold and dry sites, where the atmosphere contains a minimal amount of precipitable water. Water vapor measurements at the South Pole, in conjunction with submillimeter skydip measurements, show that the Antarctic Plateau provides the best submillimeter observing conditions on Earth. The 1.7-m diameter telescope of the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) has been exploiting these conditions for the past 3 years to study atomic carbon (CI) and J=4-3 CO emission in a broad range of physical environments in the Milky Way and Large Magellanic Cloud.

We have found from samples of [CI] emission throughout the plane of the Milky Way that [CI] arises primarily in the photodissociated skins of molecular clouds. A detection of the 492 GHz [CI] line in absorption allows the derivation of lower limits for the [CI] column density in cold foreground material in the Galactic disk. Comparison of the absorption data with the low-resolution COBE FIRAS [CI] emission line survey in the Galactic plane indicates that a substantial fraction of the atomic carbon in the interstellar medium has very low excitation and thus may be difficult to detect in emission. Observations of [CI] in the LMC indicate that photodissociation regions are enhanced in this low metallicity system.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

48.06

Atmospheric Transparency at 350 μm Wavelength

S. J. E. Radford, M. A. Holdaway (NRAO), J. B. Peterson (CMU)

Comparative measurements of atmospheric transparency are underway at three sites of current or proposed telescopes for submillimeter wavelength astronomy: the South Pole (2835 m), Mauna Kea (CSO, 4070 m), and Chajnantor, Chile (5000 m). At each site, the transparency is determined from the sky brightness measured by a broadband tipping photometer about four times per hour. These instruments are based on ambient temperature pyroelectric detectors and have resonant metal mesh filters that define a passband matched to the 350 μm atmospheric window. Two internal loads are used to calibrate the detector response. The instrument on Mauna Kea is being cross calibrated against a 225 GHz tipping radiometer, 808–846 GHz heterodyne measurements (CSO), 350 μm broadband (SCUBA on JCMT) measurements, and broadband spectroscopy (FTS on CSO). On Chajnantor, the tipping photometer is cross calibrated against a 225 GHz tipping radiometer and a broadband spectrometer (FTS). Cumulative distributions of the measured zenith optical depth indicate the amount of time at these sites suitable for submillimeter wavelength observations.

The NRAO is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

48.07

South Pole Site Quality in the 225GHz and 490GHz mm and sub-mm Bands

Richard A. Chamberlin (Caltech Submillimeter Observatory)

The South Pole is high, dry, and cold, and is therefore a very good site for performing sub-mm astronomy. In addition, the absence of 24 hour diurnal variations, and the stable weather pattern set up over the Antarctic continent, combine give the sky over the site unparalled temporal stability.

Here we present data from 1992 and 1995 which demonstrate the exceptionally good qualities of the site. The 1992 data set was obtained from an NRAO 225GHz heterodyne radiometer, and the 1995 data set was obtained using 230GHz and 492GHz heterodyne receivers on the AST/RO radio telescope. The data sets were compared to measurements from radiosonde soundings to quantify the opacity dependence on water vapor and also to quantify the dry-air opacity. At this very dry site, the dry air opacity is shown to be a significant fraction of the total observed opacity.

If time permits, we will also show some aeronomy results obtained using the AST/RO instrument. These results include measurements of the telluric carbon monoxide (CO) column abundance; measurements of the mesospheric wind velocity derived from observing small doppler shifts in CO; and measurements of the spectra from stratospheric ozone.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

48.08

Ice as a Detector Medium

P. B. Price (UC, Berkeley)

Just as seeing in the atmosphere limits ground-based optical astronomy, seeing in the Antarctic ice limits high-energy neutrino astronomy. The 1989 decision to explore locating AMANDA in the deep ice at the South Pole was based on skimpy laboratory experiments on optical properties of ice and on inadequate information about air bubbles in glacial ice. Since then, using pulsed beams of laser light at wavelengths from 337 to 510 nm, we have mapped the optical properties of South Pole ice at depths from 800 to 2350 meters. For the window of transparency between 250 and 450 nm, we attribute absorption in ice entirely to the concentration of four types of ''dust'' from precipitation of aerosols – insoluble mineral grains, sea salt grains, acid droplets, and soot. In this model, pure ice would be infinitely transparent in the absence of dust. At shallow depths scattering is dominated by air bubbles. Their contribution diminishes with depth due to the transition from bubbles to solid, transparent air-hydrate crystals. At depths below 1200 m scattering is dominated by the four dust components. Rigorous application of Mie theory, using concentrations and size distributions of the dust components modeled from direct measurements of ice cores at Vostok Station (east Antarctica), enables us to account for the optical properties of ice measured by AMANDA and to predict ''seeing'' throughout the 1300-2300 m depth relevant for AMANDA-II and for the future ICECUBE observatory. Variations in absorption and scattering lengths as a function of depth can be attributed to variations in dust concentration due to the earth's glacial stages. The background of light from radioactivity and triboluminescence is negligible. Except for bubbles at depths less than 1200 m, seeing is quite acceptable for high-energy neutrino astronomy.

Session 49: The Frontiers of Far Ultraviolet Astrophysics - I
Topical, Oral Session, 8:30-10:00am, 10:45am-12:30pm
Sierra/Padre

49.01

FUV, Introduction

George Sonneborn (NASA's GSFC)

A one-day topical session will review the observational and theoretical status of astrophysical problems where data in the 900 to 1200 Å range are essential for future advances. The session will include the study of FUV rest wavelengths at high redshifts. For example, the status of the deuterium-to-hydrogen abundance ratio will address the Milky Way and QSO absorption line systems. The FUV spectral region is well known for its unique spectral features and important scientific problems they address. The Lyman series of atomic hydrogen provides the only means to determine the production of deuterium in the Big Bang and its subsequent processing during galactic chemical evolution. The resonance doublet of the O VI ion is the highest temperature resonance line available to study the abundance and kinematics of diffuse hot gas in the disk and halo of the Galaxy and hot gas in accretion disks. The Lyman and Werner bands, the only electronic transitions of molecular hydrogen, probe cold gas in the diffuse ISM as well as the outer regions of dense molecular clouds. Strong transitions of several ionization states of carbon, nitrogen, oxygen, neon, sulphur, and argon provide unique diagnostics for studying interstellar gas and emission plasmas. This special session focuses on recent observational material and how the data limit the range of acceptable pictures. It is also intended to highlight key puzzles and describe anticipated progress from new instrumentation, in particular the Far Ultraviolet Spectroscopic Explorer mission, due to be launched in early 1999.

49.02

The Fascination of Far-UV Astrophysics

J. L. Linsky (JILA/Univ. Colorado)

A one-day topical session will review the observational and theoretical status of astrophysical problems where data in the 900 to 1200 Å range are essential for future advances. The session will include the study of FUV rest wavelengths at high redshifts. For example, the deuterium-to-hydrogen abundance ratio will address the Milky Way and QSO absorption line systems. The FUV spectral region is well known for its unique spectral features and important scientific problems they address. The Lyman series of atomic hydrogen provides the only means to determine the production of deuterium in the Big Bang and its subsequent processing during galactic chemical evolution. The resonance doublet of the O VI ion is the highest temperature resonance line available to study the abundance and kinematics of diffuse hot gas in the disk and halo of the Galaxy and hot gas in accretion disks. The Lyman and Werner bands, the only electronic transitions of molecular hydrogen, probe cold gas in the diffuse ISM as well as the outer regions of dense molecular clouds. Strong transitions of several ionization states of carbon, nitrogen, oxygen, neon, sulphur, and argon provide unique diagnos-

tics for studying interstellar gas and emission plasmas. This special session focuses on recent observational material and how the data limit the range of acceptable pictures. This session will highlight key puzzles and describe anticipated progress from new instrumentation, in particular the Far Ultraviolet Spectroscopic Explorer (FUSE) mission, due to be launched in early 1999.

The first talk of the session will summarize the critically important spectral diagnostics that reside in the FUV spectral region and show how they allow FUSE to address the main scientific objectives of FUV astrophysics. FUSE spectra will also enhance the value of longer wavelength spectra provided by HST and IUE, shorter wavelength spectra of EUVE and soon AXAF, lower sensitivity FUV spectra of Copernicus, and lower resolution FUV spectra of ORFEUS.

49.03

Deuterium in the Galaxy

K. R. Sembach (Johns Hopkins University)

Most of the deuterium in the Universe was created within a few minutes of the Big Bang, and it is generally believed that the net abundance of deuterium decreases with time due to stellar processing (astration). The present day value of the deuterium abundance should therefore reflect the imprint of Big Bang nucleosynthesis as well as the subsequent chemical evolution of the Universe. This ''history'' can be understood in part by determining the D/H ratio as a function of redshift (time), though the details of doing so have made this task difficult.

In this talk, I will discuss the data and techniques used to measure the D/H ratio in the Milky Way with space missions such as Copernicus, IMAPS, and the Hubble Space Telecope. I will also describe how upcoming measurements with the Far Ultraviolet Spectroscopic Explorer will change our limited view of the deuterium abundance in the Milky Way and how the data might be used to further our understanding of the chemical evolution of galaxies and the destruction of deuterium with time.

49.04

Intergalactic D/H, Metals, and Ionizing Background

J. M. Shull (Univ. of Colorado)

Measurements of D/H, trace heavy elements, and He II Gunn-Peterson absorption in the intergalactic medium (IGM) provide key diagnostics of the baryon density and its spatial distribution, the ionizing background radiation, and processes of star formation and chemical evolution. I will describe the current state of these measurements, together with theoretical implications for related subjects: the first quasars and starburst galaxies, IGM reionization, and stellar astration of deuterium. Two future NASA ultraviolet missions (FUSE and HST/COS) will provide powerful diagnostics of these processes at redshifts z = 2-4.

49.05

Observations of Hot, O VI-bearing Gases in Space: Past Conclusions and Future Prospects

E. B. Jenkins (Princeton U. Obs.)

Atoms that are collisionally ionized to high charge levels can serve as important tracers of very hot, diffuse gases in space. The element oxygen is particularly useful because it has a large cosmic abundance, and at a charge of +5 it becomes a lithium-like ion with a very strong resonance doublet in the far uv (λλ 1032, 1038Å). In collisional ionization equilibrium O VI exhibits a peak fractional abundance of 0.2 at $T \approx 300{,}000$K, and under most circumstances it is unlikely to be created by photoionization. Fundamental properties of hot gases in the disk and lower halo of our Galaxy have been derived from surveys of O VI absorption in the spectra of early-type stars, providing a useful supplement to information derived from studies of the diffuse, soft x-ray emission. Moreover, absorption by O VI occasionally has been identified with distant gas systems in front of quasars. Unfortunately, we have not yet performed a large-scale, systematic survey of the radiation emitted by O VI, which turns out to be an important mode for radiative cooling at the relevant temperatures.

A study of O VI absorption planned for FUSE will extend to stars out to a distance of about 4 kpc in the Galactic plane and even farther in the Galactic halo. Compared with earlier results from the *Copernicus* satellite that were limited to stars often nearer than 1 kpc, new conclusions on the distribution and properties of the hot gas will be less strongly influenced by the persistent contribution from the local material surrounding us, or by gases heated by the interaction of the target stars' stellar winds with their surroundings. In addition, the new survey should provide complete coverage over a broad range of radial velocities, and special attempts will be made to register very shallow absorption features with extraordinarily large velocity dispersions.

49.06

Far-Ultraviolet Spectroscopy of Interstellar Molecular Hydrogen

Theodore P. Snow (University of Colorado)

Molecular hydrogen (H_2) is the most abundant constituent in the interstellar medium, but cannot be observed directly except through its electronic transitions in the far-UV. To date UV observations of interstellar H_2 exist only for stars observed with the *Copernicus* satellite, which was limited to visual extinctions of 1 magnitude or less, and a few additional sources observed (often at lower resolution) with other instruments. Important gains can be made through the measurement of interstellar H_2 absorption of more heavily-reddened lines of sight, which can provide information on the total gas column densities (which are needed for analyses of abundances and depletions), chemical models, the effects of differing grain properties; and measurements of cloud physical conditions such as kinetic temperature, density, and radiation field intensity. The *FUSE* mission will provide data on interstellar H_2 for stars with total extinctions up to 5 magnitudes, lying behind material with a variety of extinction, chemical, and physical conditions, thus providing new information on the chemistry and physics of translucent interstellar clouds. This talk will provide a brief review of previous work on UV spectra of interstellar H_2, and will then focus on future work that is possible with *FUSE* and other potential far-UV observatories.

49.07

Far Ultraviolet Observations of the Neutral Interstellar Medium

Ulysses J. Sofia (Villanova University)

The far ultraviolet (FUV) spectral region contains transitions for the dominant ions of many abundant species in the neutral interstellar medium (ISM). These ions include H I, D I, C II, N I, O I, Mg II, Si II, P II, Ar I and Fe II. These species are useful for studying diffuse interstellar clouds and the physical and chemical characteristics of the dust which exists in them. The Ar I absorption features at 1048 and 1066Å are the only argon lines available which can be used to determine the neutral argon abundance in the ISM. When compared to the neutral hydrogen abundance along a sightline, the neutral argon abundance may be a useful diagnostic for determining which process, photoionization or collisional ionization, is responsible for partially ionizing any gas in a primarily neutral region. This is possible because of the large photoionization cross section of neutral argon. This suggestion will have to be tested by comparing $n(e)$ to $N(\mathrm{Ar\ I})/N(\mathrm{H\ I})$ in interstellar clouds which are abundant in free electrons. This type of analysis may also allow one to place any observed higher ion species in either classical H II regions or partially ionized neutral interstellar clouds. Results from IMAPS and *Copernicus* will be discussed.

Session 50: Pulsars in the UV and Visible
Topical, Oral Session, 8:30-10:00am, 10:45am-12:30pm
Friars

50.01

Pulsars, Introduction

Paul B. Etzel, Joseph F. Dolan (SDSU)

According to the Vector Model of pulsar emission (F. G. Smith, MNRAS, v219, 729, 1986; Comm. Ap., v15, 207, 1991; A. Lyne & F. G. Smith, "Pulsar Astronomy," Cambridge U. Press, 1990), the high-energy emission (IR to gamma- ray) comes from a different region than the radio emission (near the velocity of light cylinder rather than over the magnetic poles). Recent advances in observation of pulsars in the UV and visible coupled with theoretical advances of our understanding of pulsar emission mechanisms make a review of recent discoveries appropriate for the 1998 Summer Meeting.

The focus of this session will be on pulsars that radiate by accelerating particles away from the neutron star (the classical radio pulsars) rather than those that accrete material from a companion (the classical X-ray binary pulsar).

Topics to be discussed include:

(1) a comparison of observational results in the UV and visible, and perhaps the IR and X-ray region as well, with the predictions of the vector model; variations in pulse profile as a function of frequency as a test of the standard model.

(2) the discovery of new pulsars in the UV and visible

(3) the spectra of pulsars in the UV and visible.

(4) braking index measurements and theories of particle acceleration mechanisms; the possibility of cosmic ray acceleration occurring in this class of pulsars.

(5) using reprocessed UV pulses from X-ray binary pulsars to measure neutron star masses dynamically.

50.02

The Vector Model of Pulsar Emission: Observations in the UV and Visible

Joseph F. Dolan (LASP, NASA GSFC & Dept. Astron., SDSU)

Isolated pulsars radiate by accelerating particles away from the neutron star rather than by accreting material from a companion. According to the vector model of pulsar emission [F. G. Smith, 1986, MNRAS, 219, 729; 1991, Comm. Ap., 15, 207; A. Lyne & F. G. Smith, 1990, "Pulsar Astronomy," Cambridge U. Press], the IR to gamma-ray emission from isolated pulsars comes from a region near their velocity- of-light co-rotation cylinder. (The radio emission is generated in a different region over the magnetic poles.) A comparison of the predictions of the vector model with HST observations of the Crab pulsar and PSR B0540-69 in the UV and visible shows that the frequency dependence of both the pulse profile and polarization are consistent with the predictions of the model.

50.03

Pulsar Physics: Clues from Optical/UV Emission Models

Roger W. Romani (Stanford University)

New observational capabilities have recently provided rapid progress in measurement of rotation-powered pulsars in the near-IR through UV. We now have optical detections of ~a dozen young pulsars, color information on over half of these objects, and a few low resolution spectra. Optical pulse profiles are now available for five pulsars, and phase-resolved color changes have been seen in the spectrum of the Crab. Coupled with recent γ- and X-ray data, we are now assembling a good general picture of the non-thermal magnetospheric emission. Optical/UV emission, while energetically insignificant, plays an important role since (as in the soft X-rays) the spectrum can also contain a significant thermal component in this band.

At present, theory lags the data. We summarize the general constraints that have been deduced from the observations, arguing that the IR-UV emission is dominated by synchrotron emission from the magnetosphere above a single magnetic pole. We then describe some recent attempts to model optical pulse profiles and spectra. These models suggest that optical data are a keen diagnostic of the particle production in the magnetosphere, and show that phase-resolved spectra and polarimetry will be particularly powerful at probing the pulsar physics and connecting with other wavebands. Intriguing results are already available for the brightest pulsar, the Crab; but sensitive measurements of a typical young pulsar at $m_V > 25$ require new detector technology along with modern large telescopes.

50.04

The Isolated, Radio-quiet Neutron Star RX J185635-3754: A View of the Photosphere of a Neutron Star

F. M. Walter, P. An (SUNY Stony Brook)

RX J185635-3754 was discovered as an anomalously-bright, extremely soft X-ray source in a ROSAT PSPC image of the R CrA molecular cloud. The ROSAT PSPC spectrum is best fit as a 57eV black body, with $n_H = 1.4 \times 10^{20}$ cm^{-2}. The low column suggests that the source is foreground to the 120 pc-distant molecular cloud. At this distance the luminosity of the source is about 5×10^{31} erg s^{-1}, and the emitting area is about 480 square kilometers. We identified the optical counterpart in a pair of HST/WFPC2 images as a faint (V = 25.6) blue (U-V = −1.4) object. The U and V fluxes are close to the extrapolation of the X-ray black body to long wavelengths.

The small size and high temperature of the object suggest that it is an isolated neutron star. There is no evidence for a hard non-thermal tail, radio emission, or variability. The emitting area suggests emission from most, if not all, of the surface, and not just from a polar cap. The spectral energy distribution is consistent with a Si-ash or Fe atmosphere.

I will review the data, and then present some new evidence, including the soft X-ray spectrum from EUVE, new ground-based photometric detections, the ASCA spectrum, and the possible detection of a proper motion, that RX J185635-3754 is a million year old, cooling neutron star. Future observations of the parallax and proper motion from HST, and the X-ray spectrum from AXAF, will yield a more definitive picture, but for now it appears that RX J185635-3754 affords our best opportunity to observe and characterize the photosphere of a neutron star.

50.05

UV Spectra of Pulsars: Crab Pulsar from STIS

Theodore R. Gull (NASA/GSFC/LASP)

During the checkout phase of the Hubble Space Telescope(HST) after the Second Servicing Mission, the Crab Pulsar was observed with the Space Telescope Imaging Spectrograph(STIS) to verify timing capability of the ultraviolet Multi Anode Multi Array (MAMA) detectors (HST proposal 7108). We tested only the Near Ultraviolet (NUV) MAMA as a Guest Observer program is scheduled to observed the Crab Pulsar in the Far Ultraviolet (FUV, P. Lundqvist, HST proposal 7761). The spectrum from 1600 to 3200 A was recorded using the G230L grating with 1.6 A per pixel and 0.025 arcseconds per pixel. A total of 4800 seconds integration over two orbits was utilized to record the spectrum in time-tag mode. One additional orbit (1800 seconds) was used with the NUV MAMA in ACCUM mode to permit cross-comparison of the spectrum obtained by two different methods.

Using the data to internally derive the pulse period, which agreed very well with the radio-derived pulse period, we obtained a data cube with the coordinates of slit length, spectral dispersion and pulse profile. Different slices were taken to look for color dependency of the pulse profile across the 1600 - 3200 A spectral region. To the limit of the photon statistics, no color dependence was noticed. Moreover, we compared the spectra of the rising edges, the falling edges and the peaks of the pulse and interpulse. Again no

color changes could be detected. The interpulse portion of the profile has significantly lower photon statistics, so little can be stated about its color dependence. No evidence was found for giant pulses as have been reported in radio studies of the Crab Pulsar (Lundgren *et al.*, 1995, ApJ, 453, 433).

The STIS promises to be an excellent tool for spectroscopic and imaging timing studies of pulsars, and other rapidly varying objects, in the ultraviolet spectral region from 1175 to 3200A with angular resolutions defined by the HST wavelength-dependent point spread function. In the visible (2000 to 10500A) the STIS CCD can be used in both imaging and spectroscopic modes with exposures as short as 0.1 sec.

50.06

The Optical Spectrum of the LMC Pulsar B0540-69

Robert J. Hill (Raytheon STX, NASA/GSFC)

The Faint Object Spectrograph has been used to obtain a prism spectrum of the pulsar B0540-69, located in the Large Magellanic Cloud. The spectrum, covering 2500–5500 Å, shows a smooth continuum with several broad emission lines. While the lines are produced by the surrounding nebula, the time-averaged emission from the pulsar is the dominant source of the continuum. The observed spectral index of the continuum is $\alpha = -2.5 \pm 0.2$ between 2500 and 4500 Å. Using $E(B-V) = 0.20 \pm 0.05$ mag gives an unreddened spectral index of $\alpha_o = -1.6 \pm 0.4$. This is significantly different from the Crab pulsar ($\alpha_o = 0.11 \pm 0.13$), which is the only other pulsar with a measured optical spectrum.

50.07

Infrared Pulses from the Crab Nebula Pulsar: Implications for the Pulsar Emission Mechanism

Stephen S. Eikenberry (California Institute of Technology)

I will present high time resolution (10μs) near-infrared pulse profiles of the Crab Nebula pulsar taken with the Solid-State Photomultiplier (SSPM) photometer on the Multiple Mirror Telescope and the Palomar 200-inch telescope. In conjunction with simultaneous optical pulse profiles taken on the ground, and optical, UV, X-ray, and γ-ray pulse profiles taken from space, these data provide unique insights into the pulsar emission mechanism. In particular, I will show that the pulsar spectrum changes from the leading edges to the trailing edges of each pulse peak, with differences resolvable on timescales $\sim 100\mu$s. Furthermore, many energy dependences of the pulse shape (peak-to-peak separation, peak width, peak ratios, etc.) continue over 7 decades of energy. Meanwhile, the phases of the peak maxima appear to shift significantly with energy. These and other pulse parameters are not predicted by current pulsar emission models, and offer new challenges for the development of such models.

50.08

The Optical/X-ray Connection and the Standard Model

J. P. Finley (Purdue University)

There are only a few known cases of pulsars which are detectable as pulsed sources in both the optical and X-ray wavebands. This small group of pulsars are young and the "standard model" of pulsar emission makes definitive statements about the light distribution, and the phasing of the pulsations in the two wavebands. This talk will focus on this group of young pulsars and will summarize the observational data with respect to pulse shape and the absolute phasing of the light distribution. New results, recently obtained with simultaneous RXTE and CTIO observations, will be presented and compared to expectations of the standard model.

50.09

X-Ray Emission From Rotation-Powered Pulsars

A. K. Harding (NASA/GSFC)

Pulsed emission at X-ray energies has been detected from a number of pulsars. The bulk of these detections were made by ROSAT in the soft 0.1 - 2 keV band, where the emission appears to be a thermal blackbody, due either to neutron star cooling and /or heating of the polar cap by returning particle flux. Recently, detections of a handful of pulsars by ASCA and RXTE have revealed that the emission is very different in the hard X-ray band, 1 - 30 keV, where it appears to have a non-thermal, power law spectrum. In some cases like Vela, the hard X-ray emission is a smooth extension of the gamma-ray spectrum seen at higher energies, but in other cases like Geminga, the connection to higher energies is not clear. I will discuss some new results in both observations and models of pulsar X-ray emission, the connection to the UV and optical emission, and what it tells us about the site of particle acceleration and radiation.

50.10

Theory of Braking Indices

A. Melatos (Astronomy Dept, UC Berkeley)

A variant of the vacuum-dipole theory of pulsar spin-down is presented that correctly predicts the braking indices of the Crab pulsar, PSR B0540 − 69 and PSR B1509 − 58 as measured from absolute pulse numbering. In the theory, the neutron star and its inner magnetosphere are modeled phenomenologically as a single unit, a conducting sphere of radius r_v rotating rigidly in vacuo. The 'vacuum radius' r_v is chosen to correspond to the point in the magnetosphere where the outflowing plasma becomes three-dimensional and cross-field currents can flow. For young, Crab-like pulsars, one finds $r_* \ll r_v$; the model therefore differs from the standard vacuum rotator, which has radius r_* and is treated as point-like.

Given three observable pulsar parameters — the rotation frequency ω, its time derivative $\dot{\omega}$, and the angle α between the rotation and magnetic axes —and with zero free parameters, the theory yields braking index values $n = \omega\ddot{\omega}/\dot{\omega}^2$ for the above three pulsars that agree with timing data to 4 per cent. The theory also makes testable predictions regarding the second deceleration parameter m [e.g. $m < n(2n - 1)$] and implies that n approaches 3.0 for every pulsar as it ages (with consequences for the $P-P$ diagram). The success of the theory has several implications for magnetospheric structure, e.g. the role of charge separation in the inner magnetosphere, and the dominance of displacement current over conduction current beyond r_v.

50.11

Reprocessed UV Pulses from Vela X-1

Patricia T. Boyd (USRA and LHEA NASA/GSFC), Joseph F. Dolan (LASP NASA/GSFC), Robert J. Hill, Jeffrey M. Silvis (HSTX NASA/GSFC), Edward L. Robinson (U Texas, Austin), Jeffrey W. Percival, Robert C. Bless (U. Wisconsin), G. W. van Citters (NSF)

The High Speed Photometer (HSP), a first generation scientific instrument aboard the Hubble Space Telescope, observed a number of X-ray binary systems in the ultraviolet for evidence of x-ray pulses being reprocessed in the atmospheres of the main sequence primaries. One of these systems, Vela X-1, displayed UV pulses at a period quite near the X-ray pulsar period. Analysis of archival IUE data indicates this reprocessed radiation is mainly line radiation, whose phase variation is consistent with the interpretation that a fraction of the companion stars surface is reradiating the pulses.The compact companion in this system, presumably a neutron star pulsar, has the highest neutron star mass measured by previous techniques. The maximum NS mass has ramifications on the equation of state of neutron star matter, and so is an important parameter to measure accurately. If we observe pulses from both the primary and the compact companion, this system may be studied as a double-lined spectroscopic binary, yielding an estimate for the mass twice as accurate as previous measurement techniques.

Session 51: Galaxy Evolution and the Intergalactic Medium
Display Session, 10:00am-6:30pm
Atlas Ballroom

51.01

The Physical Parameters Underlying the Sequence of Early-Type Galaxies

M. A. Pahre (Caltech and CfA), S. G. Djorgovski (Caltech), R. R. de Carvalho (Caltech and ON/Brazil)

The physical parameters varying along the sequence of early-type galaxies are explored using the Fundamental Plane (FP) correlations in the local universe and in distant clusters.

The nearby galaxy samples in the *UBVRIK* bandpasses are drawn from a new survey (Pahre 1998) and the literature. A distant-independent parameterization of $\Delta(\log r_{\rm eff} - 0.32\langle\mu\rangle_{\rm eff})$ against $\log\sigma_0$ shows that the slope A of the FP relation $r_{\rm eff} \propto \sigma_0^A \langle\Sigma\rangle_{\rm eff}^B$ increases systematically with wavelength from U to K. A model is constructed to describe this variation of the FP slope, the slope of the Mg_2–σ_0 relation, and the effects of stellar populations gradients. This model shows that there are systematic variations of up to a factor of three in age and metallicity along the full range of the early–type galaxy sequence (in the sense that the most luminous galaxies are the oldest and the most metal rich), and that a wavelength–independent effect (such as dynamical homology breaking or systematic variations in dark matter content) is required. This model predicts that the slope of the FP evolves: the power-law index A should decrease with redshift.

A large sample of $>$ 100 early–type galaxies in six clusters at $0.1 < z < 0.6$ is studied using the K-band FP. The slope of the FP is shown to evolve slowly and systematically with redshift in a manner which is in modest agreement with the model predictions based on nearby galaxies. This occurs despite the appearance that the "average" elliptical is evolving passively from a single burst at high redshift. The evolving slope of the FP demonstrates that age variations of up to a factor of two or three exist along the early-type sequence.

51.02

The Bright Galaxies in the Hubble Deep Field

Y. Park (JHU), R. J. Allen, H. C. Ferguson, N. Panagia (STScI)

The Hubble Deep Field (HDF), which was taken from 1995 December 18-30, is the deepest view of the universe. Except a few stars in our Milky Way, most of objects seen in the HDF are very distant galaxies, some of which are nearly as faint as 30th magnitude. The HDF shows a surprising variety of galaxies in the shape and color which helps understand the evolution of the galaxies. The HDF makes it clear that the universe at high redshift looks rather different that it does at the current epoch and galaxies evolve in color and shape. We make a image showing the trend of change of 'big' galaxies in color and shape. We sample all galaxies whose redshifts are measured to date to trace galaxy evolution in high redshift. To compare the real sizes of the galaxies, we construct the true color images of galaxies at constant physical scale by fixing cosmological parameters which affect the sizes of galaxies (h=0.65,Ω_0=0.1,Λ=0). The true color images of galaxies are assembled from separate images taken in F450W, F606W, and F814W bands. We generate true color images based on logarithmic scale to make the images realistic to human eyes. A few facts on the images are also discussed.

51.03

Evidence for an Environmental Dependence of the E/S0 Ridgeline

C. Stoughton, J. Annis, D. L. Tucker (Fermilab Experimental Astrophysics Group), Y. Hashimoto (Yale/OCIW), T. A. Mckay, J. A. Smith (U. Michigan Physics Dept.)

The Las Campanas Redshift Survey (LCRS) is a galaxy survey which extends to a redshift of 0.2 and which is composed of 6 alternating 1.5° × 80° slices – 3 each in the two galactic caps. Completed in 1996, the LCRS contains approximately 26,400 galaxy redshifts. b_J-band photometry from the Automated Plate Measuring Machine (APM) Galaxy Survey, LCRS R-band photometry, and multi-band CCD photometry of many of the fields permit the derivation of rest-frame colors for much of the LCRS Southern Galactic Cap sample. A "friends-of-friends" group-finding algorithm has been used to break this color sample into three additional subsets: galaxies in groups, galaxies in clusters, and galaxies in the richest clusters. Taking the galaxy concentration index data of Hashimoto *et al.* (1998), we were able to extract E/S0 ridgelines for these samples. Plotting color vs. M_R for the different samples' ridgelines, we have found that the slope of this relation becomes progressively steeper as one goes from the full sample (which has no significant slope) to one containing only galaxies in the richest clusters. We explain this environmental dependence in terms of stronger feedback of processed stellar material in star formation within cluster galaxies.

51.04

Evolution in Emission-line and Broad-band Galaxy Luminosity Functions to Redshift Unity

D. W. Hogg (IAS), R. Blandford, J. G. Cohen (Caltech), M. A. Pahre (CfA)

An analysis of spectroscopic data on faint galaxies in an 8-arcmin diameter region centered on the Hubble Deep Field is presented. Source detection and photometry is performed in the U_n, G, $\mathcal{R}$ and K_s-band images to create catalogs complete to $U_n = 25$, $G = 26$, $\mathcal{R} = 25.5$ and $K_s = 20$ mag. Keck Telescope spectroscopy exists for over 500 sources in the sample; the median redshift is 0.6.

The rest-frame equivalent widths of the [OII] 3727 Å emission line are measured as a function of galaxy flux, color and redshift. The probability that a source of a given flux, color and redshift has its [OII] line detected is estimated. [OII] line luminosity functions and integrated [OII] line luminosity densities are computed; they show strong evolution, implying a much higher star formation rate density at redshifts $z\sim1$ than locally.

The B-band luminosity function for the $\mathcal{R}$-selected sample is computed using an estimate of the probability that a source is assigned a redshift given that it has been observed spectroscopically, based on the [OII] detection probability. The luminosity function is flat (constant number per log luminosity) and consistent with local determinations except for a higher overall normalization. No evidence is found for dependence of the luminosity function on redshift or environment, but the blue galaxy luminosity function is more dwarf-rich than the red.

51.05

Cosmic Evolution of CI, CII, and CO Luminosity of Galaxies

C. Campbell, J. Bally (University of Colorado)

We calculate the gas-phase abundances of neutral carbon (CI), ionized carbon (CII), and carbon monoxide (CO) as functions of time and redshift. The analysis of the millimeter and sub-millimeter wavelength lines of these carbon species is a powerful probe for studying galactic evolution and cosmology. Our galactic models use low, intermediate, and high mass stars and include Type II supernovae, infall, and various star formation rates. The interstellar gas phase abundances of carbon and oxygen are computed as functions of the gas mass fraction. For models without infall, the gas phase abundance of carbon bearing species peaks when about 70% of the baryonic mass of a galaxy has been consumed by star formation. The models also predict a much higher oxygen abundance relative to carbon in the early ages of the galaxy.

The fraction of gas-phase carbon in CI, CII, and CO phases is then determined from models of photon-dominated regions. We include the attenuation of radiation by dust grains and self-shielding of CO to find the average column densities of CI, CII, and CO. Galactic evolution models with varying star formation rates, initial mass functions, and the effect of Hubble type are discussed. We investigate how star formation in energetic bursts as well as in more continuous rates affects the metallicity and molecular gas evolution. We also explore whether a time-dependent initial mass function, the addition of a Population III star formation era, is needed to produce the rapid enrichment seen in high redshift quasars.

51.06

Distant Ring Galaxies and the Galaxy Interaction Rate at High Redshift

M. D. Reed, R. J. Lavery, A. J. Remijan (Iowa State Univ.)

We present the current state of our ongoing survey of deep HST images, obtained from the HST archive, to identify distant ring galaxies. These random fields provide an unbiased selection of distant field galaxies which have been visually inspected for galaxies having a ring morphology. Ring galaxies, most of which are collisionally induced, have regions of enhanced star formation rates, making them easily identifiable at high redshifts.

We will present the photometric and physical properties of our initial sample of distant ring galaxies and compare them to the Few and Madore (1985) sample of nearby ring galaxies. We will also use this distant sample to calculate the exponent, m, of the interaction rate of galaxies as a function of z, which is parameterized as: $rate = (1 + z)^m$. Our goal is to place a lower limit on the power-law exponent, m, which in previous studies has ranged from 0 to 4.5.

Our long term aim is to produce a large sample of distant ring galaxies to be used in a redshift survey to directly measure m as a function of z. This sample of ring galaxies will also be useful for future studies on starburst galaxies, galaxy dynamics, galaxy evolution, and may lead to a determination of Ω.

51.07

High Resolution Spectra of Low Redshift Damped Lyα Absorption Systems

R. D. Cohen, E. A. Beaver, V. T. Junkkarinen, R. W. Lyons, H. E. Smith (CASS/UCSD)

We have been able to form a fairly complete picture of the galaxy responsible for the z_a=0.395 absorption line system in PKS 1229–021 by combining Keck HIRES and LRIS spectroscopy with observations taken with the Hubble Space Telescope. The image of the absorber is consistent with the inclined disk of a moderately luminous spiral galaxy. We have not been able to detect the continuum from this galaxy spectroscopically, but our LRIS spectra show emission from [O II] λ3727 which can be interpreted to be indicative of star formation at the rate of a few $M_\odot$ per year. The HIRES spectra clearly show an ''edge–leading'' absorption profile. Prochaska and Wolfe have predicted that the velocity of the center of mass of the absorbing galaxy should fall near one edge of the absorption profile if the damped Ly α systems are due to the rotating disks of spiral galaxies. The [O II] emission velocity is consistent with this, but there is some ambiguity due to the doublet nature of the [O II] emission. Although the absorption lines of the abundant elements are saturated in the components which correspond to the H I absorption, we have been able to measure accurate column densities for Ca II, Ti II, and Mn II for comparison with the H I column density determined from low resolution HST/FOS spectra. The abundances are compatible with approximately 0.1 of solar, with little or no dust, but they are also consistent with lines of sight toward ζ Oph through warm interstellar clouds.

HIRES observations of the z_a = 0.692 absorption line system in 3CR 286 will also be discussed, after the data are fully analyzed.

This work is part of the Goddard High Resolution Spectrograph Guaranteed Time Observations and is supported by NASA grant NAG5–1858 and the NSF.

51.08

Highly Ionized HVCs: Intergalactic Gas in the Local Group?

K. R. Sembach (JHU), B. D. Savage (U. Wisconsin), L. Lu (Caltech), E. Murphy (JHU)

We have recently identified several high velocity (<−100 km/s) clouds in the directions of Mrk 509 and PKS 2155-304 that have unusual ionization properties. They exhibit strong CIV absorption with little or no low ion (CII, SiII) absorption or HI 21cm emission. As the closest known analog to the outer diffuse halos of damped Ly-alpha absorbers and the low N(HI) metal line absorption systems seen in the spectra of high redshift quasars, these CIV-HVCs present unique opportunities for studying the conditions within the Milky Way halo and nearby intergalactic gas. We present new GHRS intermediate-resolution measurements of the absorption lines within these CIV-HVCs and study the ionization properties of the gas in detail. The present data represent the most complete set of measurements available for studying the ionization conditions within high velocity clouds. The CIV-HVCs have ionization properties consistent with photoionization by extragalactic background radiation, though some contribution by collisional ionization within a hot plasma cannot be ruled out. The clouds are probably low density [n(H) 10^4 cm^{-3}], large [greater than several kiloparsecs], and mostly ionized [n(H)/n(HI) 10^{-3}] regions located well beyond the neutral gas layer of the Galaxy. The presence of weak HI-HVCs detected through their 21cm emission near both sight lines indicates that the CIV-HVCs trace the extended, ionized low density regions of the HI-HVCs. Several lines of evidence, including very low thermal pressures, favor a location for the CIV-HVCs in the very distant Galactic halo or the Local Group. If the clouds are intergalactic in nature, their metallicities could be [Z/H] -1 or lower, but higher metallicities are favored if the clouds are located in the distant Galactic halo.

51.09

Local HVC System and Low z Ly-α Forest

C. Mallouris, D. G. York (U. Chicago), K. Lanzetta (SUNY at Stony Brook)

The possible connection between High Velocity Clouds (HVCs) and Ly-α absorbers seen in QSO spectra at low redshift, and the detectability of such cloud systems in other groups of galaxies, is investigated. HVCs are unlikely to be isolated phenomenta to our Galaxy. If they are infalling matter on galaxies, or groups of galaxies, such systems of other galaxies should appear as QSO Ly-α absorbers at the corresponding galaxy redshifts. This should occur in the same way that Galactic HVCs appear as absorbers toward AGNs which happen to fall in the lines of sight to these clouds. We examine the possibility that the low z Ly-α forest in QSO spectra is partly related to systems of HVCs in intervening groups of galaxies. The mass spectrum of HVCs, extrapolated from 21cm observations to lower column densities is consistent with the high incidence of Ly-α absorbers at low z. The source function for the transient HVC gas can be assumed to be the dwarf galaxies in the groups.

51.10

Spectroscopy of QSO Triplets: Probing the Shape of Lyman Alpha Forest Absorbers

A. P. S. Crotts (Columbia University)

We present data from three groups of three QSOs apiece with the aim of using the absorption-line spectroscopy of intervening gas to determine the size, clustering and particularly the shape of the objects which give rise to the Lyman α forest. These three triplets span comoving separations of 0.5 to 5 Mpc (for H_0 = 100 km s^{-1} Mpc^{-1}), primarily at the lower end of this range, which are a good match to the size of objects with low H I column densities found in recent numerical simulations of the hydrodynamic and gravitational evolution at redshifts of ~ 2-3. We present expanded results from the statistical techniques outlined in Crotts & Fang (1998) using triplets to measure the projected shape, velocity structure and absorber linestrength homogeneity as indications of the morphology of the absorbers. We also

combine these results with other absorption-line data from QSO sightline pairs to study the clustering and size of absorbers and to sense large scale structure in the H I distribution. We also discuss how these constraints affect estimates of the (highly significant) contribution of Lyman α forest absorbers to the total baryonic content of the Universe.

51.11

Lyman-alpha Cloud Parameters at High Redshift

Walid J. Azzam (U.A.E. University)

An analysis of a recent Lyman alpha cloud data sample containing more than 400 lines with redshift between 3.4 and 4.1 is presented. The distributions of the neutral hydrogen column density and of the Doppler width parameter are studied. The dependence of these two parameters on redshift and their correlation with one another is also investigated. Our analysis indicates that the cumulative distribution is a more effective tool than the differential distribution in analyzing the column density and the Doppler parameter since no binning is involved. The distrbution of the column density is more complicated than what is commonly believed, since it cannot be fitted with a power law or a double power law. There is a paucity of Lyman alpha lines with Doppler parameters less than 15 km/s indicating a possible lower limit on cloud temperatures of about 13,500 K. Although the column density and the Doppler parameter display a similar dependence on redshift, their correlation with one another is shown to be statistically weak.

Session 52: Source Surveys and CMB Radiation Display Session, 10:00am-6:30pm Atlas Ballroom

52.01

Results from the Columbia/VATT Microlensing Survey of M31

R. Uglesich, A. P. S. Crotts (Columbia U.), A. B. Tomaney (U. Washington), G. Gyuk (SISSA)

We present the results of a search for microlensing activity in the outer bulge and inner disk of M31 due to masses in M31 and the Galaxy. We have obtained data for the 1994-1997 observing seasons with the 1.8m Vatican Advanced Technology Telescope, KPNO 4m, MDM 1.3m McGraw-Hill Telescope and 2.5m Isaac Newton Telescope. Variability is detected and monitored using the technique of ''difference image photometry.'' From the 1995 data, we have 4 events consistent with microlensing due to masses of about 1 $M_{\odot}$ and additonal baseline coverage from data obtained in 1996 and 1997 confirm that these events are inconsistent with being long-period variable stars. In addition, we present candidate microlensing events discovered in the 1996 and 1997 seasons and discuss the potential for an expanded survey using newly available wide-field CCD imagers which could yield dozens of events per season.

52.02

Using NICMOS to Extend the Infrared Surface Brightness Fluctuation Distance Scale

Joseph B. Jensen (Gemini 8m Telescopes Project), John L. Tonry (IfA, U. Hawaii), Roger Thompson (Steward Obs.), Tod Lauer, Edward Ajhar (NOAO), Marc Postman (STScI), Marcia Rieke (Steward Obs.), Ray Weymann (Carnegie Obs.)

Infrared surface brightness fluctuations (IR SBFs) are much brighter than their optical counterparts and can be measured to greater distances. We calibrated the K-band SBF distance scale and demonstrated that ground-based observations can reach $\sim$7000 km s^{-1}. NICMOS on the Hubble Space Telescope, with its low background, makes it possible to extend the IR SBF distances scale further, possibly beyond 10,000 km s^{-1}. We have begun to measure SBF distances in the F160W (background minimizing) filter to a collection of galaxies distributed uniformly around the sky and reaching 10,000 km s^{-1}. Galaxies were chosen to minimize sensitivity to local bulk motions, and peculiar motions of the most distant galaxies in our sample should be small compared to their Hubble velocities. Our sample has enough overlap with other optical and IR SBF surveys to make a careful calibration of the F160W SBF distance scale possible. We present initial results for the first few galaxies observed with NICMOS and compare to other IR and optical SBF measurements.

52.03

The Sandage Two-color (U,B) Survey of the Galactic Plane: Status Report on the Continuing Search for Faint UV-Bright Objects

H. H. Lanning (CSC/STScI), M. Meakes (STScI)

The examination of the Sandage two-color photographic survey of the galactic plane taken in support of the *Uhuru* X-ray satellite project (1969-1972) has continued and has produced more than 300 new faint UV-bright sources within the past two years. Two new DA white dwarfs were confirmed in March by Deutsch and Margon from the latest published list. White dwarfs, CVs and suspected novae are just a few of the types of interesting objects being found in this deep (B = 20+ limiting magnitude) and extensive survey. The initial intent of the survey was to identify and study the optical counterparts of newly detected x-ray sources. More than 100 6.6°×6.6° plates were taken with the Palomar 48-in. Oschin Schmidt telescope. No optical identifications were successfully made, due in large part to the poor positional accuracy of the x-ray sources determined by *Uhuru*. Visual examination of a selected sample of the double-exposed U and B plates did, however, result in the identification of a number of interesting objects including a new cataclysmic variable, a new DO white dwarf and several peculiar objects. The potential for the identification of low-luminosity stars, binary systems and old novae was clear thus supporting the continuation of the analysis. In recent years, three additional catalog listings have been published and a fifth is nearing completion. Several new white dwarfs, potential old novae and variable stars, as well as another CV, have been subsequently identified.

We present in this poster paper a review of the survey project and analysis and provide an update on the current status of the overall project.

52.04

HST Snapshot Survey of 3CR Radio Source Counterparts. III. Radio Galaxies with z<0.1

A. R. Martel, S. A. Baum, W. B. Sparks, E. Wyckoff, J. A. Biretta, D. Golombek, F. D. Macchetto (STScI), P. J. McCarthy (Carnegie Inst.), S. de Koff, G. K. Miley (Leiden Observatory)

We present and describe optical counterparts to forty-six 3CR radio galaxies of redshifts less than 0.1 that were imaged with HST's WFPC2 camera through the broad-band F702W filter as part of the 3CR Snapshot Survey.

At the 0″.1 resolution of the images, a wealth of detail is visible. Approximately 87% of the galaxies are ellipticals and nearly all reside in groups or clusters of galaxies of various richness and compactness. Nearby elliptical companions of slightly smaller size and mass are common. Dust is prevalent in the cores of the 3C hosts — nearly half of the galaxies possess some type of dust structure, such as irregular dust lanes, filaments or disks. Besides the well-known dust disks of 3C 264 and 3C 270, we have found five new candidates in 3C 31, 3C 40, 3C 296, 3C 449, and 3C 465 as well as in the central regions of the nearby neighbors of 3C 31 and 3C 465. The outer isophotes of the host galaxies harboring dust disks are often boxy. Our sample includes six confirmed optical synchrotron jets in 3C 15, 3C 66B, 3C 78, 3C 264, 3C 274, and 3C 371, or approximately 13% of the sample. Unresolved nuclei, consistent with the PSF of WFPC2, are found in 43-54% of the galaxies and in the majority of galaxies with dust disks and optical jets.

52.05

Pearson-Readhead VLBI Survey Sources Observed with the VSOP Space VLBI Mission

S. J. Tingay, R. A. Preston, D. W. Murphy, D. L. Meier (JPL), T. J. Pearson, A. C. S. Readhead (Caltech), H. Hirabayashi, H. Kobayashi (ISAS), M. Inoue (NRO)

The VSOP Space VLBI mission uses the HALCA spacecraft, launched from Japan in February 1997, in conjunction with ground radio observatories around the world to create a high resolution radio-wavelength imaging facility. We are using this unique facility to observe a complete sample of Pearson-Readhead Survey sources (Pearson and Readhead, 1988 ApJ 328, 114) at 4.8 GHz, to determine core brightness temperatures and jet properties at higher resolution than previously attempted. In addition we are obtaining matched-resolution 15 GHz observations using the VLBA at epochs close in time to the space VLBI observations to investigate the spectral indices of these sources at high resolution. The first results from this project will be presented.

52.06

IR-Radio Correlation Using the NVSS and the 1.2 Jy IRAS Catalog

N. Molayem, E. Wright (UCLA)

We have correlated infrared fluxes in the IRAS 1.2 Jy Survey Redshift Data (Infrared Astronomical Satellite), (Fisher et al., 1997) with radio fluxes in the NVSS Source Catalog (NRAO/VLA Sky Survey), (Condon *et al.*, 1996) in order to see whether the radio absorption by the intergalactic medium (IGM) claimed by Big Bang critic Eric Lerner actually exists. The reason that this is important is that the conventional interpretation of the cosmic background radiation (CBR) as a relic of the Big Bang assumes that the intergalactic medium (IGM) is highly transparent to radio frequency radiation. We have chosen infrared fluxes for 178 galaxies selected randomly from 3920 available sources from the 1.2 Jy IRAS catalog. The Infrared flux interval is from 1.2 Jy to 10 Jy. Their corresponding radio fluxes were taken from the NVSS source catalog. The analysis of the plot of these two luminosities shows a non-linear correlation in which the radio luminosity for a given IR luminosity is independent of distance. When a redshift dependent term is added to this correlation, the improvement in the fit is statistically insignificant.

52.07

Analysis of Results from the Dwingeloo Obscured Galaxies Survey

A. Rivers, P. A. Henning (UNM), R. C. Kraan-Korteweg (U. Guanajuato), O. Lahav (U. Cambridge), W. B. Burton (U. Leiden)

Optical and far-infrared searches for galaxies fail near the Galactic plane, the so-called "Zone of Avoidance" (ZOA). Fortunately, surveying at 21-cm succeeds in cases of large optical depth and far-infrared confusion. The 25-m Dwingeloo radiotelescope is currently surveying the northern ZOA (30 deg $< l <$ 220 deg; $|b| <$ 5.25 deg) at 21-cm, looking for HI galaxies within the velocity range 0-4000 km/s. In addition to tracing large scale structures in optically obscured regions, the resulting sample will be used to study the HI mass function of galaxies in various environments.

A shallow (5 min/pointing) survey for massive galaxies has been completed, yielding 5 detections, 2 of which were previously unknown. Dwingeloo 1, a spiral galaxy in the IC342/Maffei group was the most significant nearby source. The shallow survey has ruled out the existence of a nearby Andromeda-class galaxy in the northern ZOA that would significantly affect the local gravitational potential.

A deeper (1hr/pointing) survey is now around 50 percent complete and has yielded approximately 40 detections to date, including a few sources in the local void. Insights gained into local large scale structure and a preliminary HI mass function derived from the survey detections will be presented. In addition, efforts to quantify foreground extinction for heavily obscured galaxies will be discussed.

52.08

First Results from the HI Parkes Southern Zone of Avoidance Survey

P. A. Henning (UNM), L. Staveley-Smith, R. D. Ekers (ATNF), A. J. Green (U. Sydney), R. F. Haynes (ATNF), S. Juraszek (U. Sydney), M. J. Kesteven, B. S. Koribalski (ATNF), R. C. Kraan-Korteweg (U. Guanajuato), R. M. Price (ATNF), E. M. Sadler (U. Sydney)

The development of the Parkes 21-cm multibeam receiver allows a rapid mapping of the distribution of optically- obscured HI galaxies behind the southern Milky Way. The survey, expected to be completed by early 1999, will map the Zone of Avoidance (ZOA) between longitudes 212° and 36°, between latitudes $-5°$ and $+5°$, covering the redshift range -1200 to 12700 km/s. The eventual $5-\sigma$ sensitivity limit is estimated to be 10 mJy/beam, which should produce a catalog of several thousand previously unknown galaxies.

A shallow survey for high peak HI flux density objects has uncovered about 100 galaxies, including many in the heavily-obscured Great Attractor region. The first hidden galaxies discovered through the survey to be mapped with the Australia Telescope Compact Array indicate that low HI column density systems may be common in the final catalog.

52.09

A Redshift Survey in the Field J0053+1234

J. G. Cohen (Caltech), D. W. Hogg (Caltech and Institute for Advanced Studies), R. Blandford (Caltech), M. A. Pahre (Caltech and Smithsonian Astrophysical Observatory)

Redshifts have been obtained for the sample of 189 objects with $K < 20$ mag in a field 2×7.3 arc-min^2 at J005323+1234. with 84% completeness, as well as for 15 additional nearby objects. We find that the extremely red objects in the sample with redshifts are absorption line dominated systems with $z \approx 1$.

As shown in our earlier work, more than half of the galaxies lie in five peaks in the redshift histogram. We find that the strong redshift peaks are populated largely by galaxies with spectra dominated by absorption lines. Emission line dominated galaxies avoid these structures, which have velocity dispersions that are too small for clusters of galaxies. These structures appear to be bound groups of galaxies similar to groups observed locally with masses larger than that of the Local Group but smaller than that of a typical cluster of galaxies. Groups of galaxies, like clusters of galaxies, must therefore be stable structures that have been in existence for a long time; they have not collapsed and formed recently.

The most luminous galaxies appear to reside almost exclusively in these redshift peaks. Their clustering properties must be quite different from those of the emission-line dominated galaxies. Furthermore the spectral type assigned to the brightest galaxies in strong peaks shifts progressively away from absorption dominated quiescent systems at low z to systems with significant signs of recent star formation at higher z.

Even those galaxies not in the strongest redshift peaks often are found in small groups. Only 9% of the sample may be truly isolated. Most of these apparently isolated galaxies may well have companions fainter than the survey limit or just outside the spatial boundary of the survey.

52.10

A Pointwise Dimension Analysis of the ACO Catalog

J. Best (Shepherd College)

The aim of this paper is to explore the use of a statistical technique known as the pointwise dimension in the description of large-scale structure. The pointwise dimension, or PD, has its basis in the field of fractal geometry, and has already been particularly illuminating for the study of correlations between galactic morphology and environment (Best, Charlton, Mayer-Kress, 1996, ApJ, 456, 55).

The catalog subject to examination is the ACO cluster catalog (Abell, Corwin, Olowin, 1989, ApJS, 70, 1). I have found that 2D angular and projected separation analyses show that the clustering of the ACO catalog is not similar to that of a random catalog even on very large scales. KS tests show a statistical difference between the catalogs, and histograms bear out a difference in appearance. 3D studies of the ACO catalog show that the lack of statistical difference between a random catalog and the ACO catalog does not occur until scales of roughly 200 Mpc. This value would fall in between claims for the value of the onset of homogeneity on scales under 100 Mpc and claims that homogeneity does not exist even on scales of 1000 Mpc.

52.11

The Spectrum of Mass Fluctuations as Derived from the Weak Lensing of FIRST Radio Sources

D. J. Helfand, S. Brown, M. Kamionkowski, C. Cress (Columbia U.), A. Refregier (Princeton U.), R.H. Becker (IGPP & UC Davis), R. L. White (STScI)

Large-scale mass inhomogeneities in the Universe induce correlated distortions in the shapes of background sources via weak gravitational lensing. This effect is on the verge of detectability on scales of 10 arcmin in several recent optical surveys. In most such surveys, however, the mean background galaxy redshifts are much less than 1, limiting the pathlength over which the gravitational lensing signal can accumulate. Furthermore, the angular scales probed are in the nonlinear regime of structure formation, and are thus less cleanly mapped back to the primordial mass fluctuation spectrum. Here, we report on an effort to use the FIRST survey to measure the weak-lensing signal from a large (400,000 member) population of distant radio sources. The mean redshift of FIRST sources is z 1, making them the largest sample of high-redshift objects available. Furthermore, we probe the correlation function of shape distortions on scales of 30 arcmin to 3 degrees, well within the linear growth regime. We calculate the correlation function of the radio source ellipticities and compare it to our theoretical predictions for a variety of cosmologies and assumptions about the radio source redshift distribution. We examine in detail several important systematic effects including the change of the shape of the VLA synthesized beam as a function of declination and the hour-angle of the observation, and the effect of correlated noise in VLA images on the correlation signal. We find the latter effect is from 1 to 2 orders of magnitude smaller than the expected signal, and develop a correction procedure for the former. We present the corrected ellipticity correlation function, discuss its implications for large-scale structure formation, and explore prospects for future improvements in our analysis.

This work is supported by grants from the National Geographic Society, the NSF, NASA, and Sun Microsystems.

52.12

The Spatial and Angular Three-Point Correlation Functions of a Biased Mass Distribution in CDM Models

A. Buchalter, M. Kamionkowski (Columbia University)

We investigate the predicted three-point correlation function (3PCF) for an arbitrary tracer mass distribution in a variety of CDM models. In particular, we derive the leading order results for the spatial and angular skewness (one-point statistics), as well as the full spatial and angular 3PCFs (n-point statistics), including their dependence on cosmological parameters, the shape and evolution of the power spectrum, and on the bias, which is allowed to be non-linear and/or evolving in time. The primary dependence of the derived quantities is found to be on the bias, with a significant bias leading to a flattening of the dependence of the one-point statistics on smoothing radius, and of the n-point statistics on configuration shape. For the one-point statistics, we find a degeneracy not only between the bias and cosmological parameters, but between different bias scenarios alone. These degeneracies are alleviated by the full geometric information contained in the n-point statistics, allowing independent constraints on Ω_0, the primordial power spectrum, and on the bias.

52.13

Imaging the Cosmic Microwave Background: the Degree Angular Scale Interferometer

J. Kovac, J. E. Carlstrom, M. Dragovan, W. L. Holzapfel, and N. W. Halverson (University of Chicago)

The development of low-noise, broadband millimeter-wave amplifiers has made interferometry the technique of choice for precision ground-based measurement of the cosmic microwave background (CMB). The Degree Angular Scale Interferometer (DASI) is an instrument designed to image the CMB over large regions of the sky. Its 13 element array is configured to optimize sensitivity to the CMB angular power spectrum from $\ell = 160$ to $\ell = 710$, with single-field resolution of $\Delta\ell \approx 30$. Each array element consists of a 20-cm diameter lensed corrugated horn and a cryogenic HEMT amplifier-based 26 - 36 GHz receiver. All 13 elements, along with the 10 $\times$ 1 GHz bandwidth complex correlator, are mounted to a single 1.6m diameter aperture plate, which is steerable by the telescope about three axes: azimuth, elevation, and the boresight axis. This compact design eliminates the need for delay lines, provides flexibility in sky and u,v coverage, and increases control over instrument systematics. It also will permit efficient installation of the instrument at its observing site, the South Pole, where excellent atmospheric transparency and stability offer ideal conditions for large-field interferometry. Construction of the telescope will be completed in Summer 1998, and DASI will be deployed at the South Pole for year-round operation starting in November 1999.

52.14

Anisotropy in the Cosmic Microwave Background: Results from Python V

K. Coble, J. Kovac, M. Dragovan, N. Halverson, W. Holzapfel (U. of Chicago), D. Alvarez, J. B. Peterson, G. Griffin, M. Newcomb (Carnegie-Mellon U.), K. Miller (U. of Colorado), S. R. Platt (U. of Arizona), G. Novak (Northwestern U.), S. Dodelson (Fermilab), K. Ganga (IPAC/Caltech), L. Knox (CITA)

We present observations of the microwave sky made with the Python experiment in its fifth year of operation at the Amundsen-Scott South Pole Station in Antarctica. The Python telescope was fitted with a HEMT amplifier-based radiometer, yielding sensitivity to the microwave sky from 37-45 GHz in two frequency bands for each pixel in a 1×2 array, each pixel with a one degree beam on the sky. The instrument densely samples $\sim$ 500 square degrees on the sky, which includes the fields measured during the previous four years of Python observations. Interpreting observed fluctuations as anisotropy in the cosmic microwave background radiation, we place constraints on the angular power spectrum of fluctuations in several different multipole bands up to $l\sim200$ ($\sim$1 degree).

52.15

On the Possibility of an Elastic Space Model of the Metagalaxy

Valeriy P Polulyakh (Continuum)

According to the Hot Big Bang Model (HBBM), the Universe began as a hot, nearly homogeneous mixture of elementary particles. The observations of the last three decades have revealed considerable unexpected data about the structure and population of its visible part, the Metagalaxy (Met). The basic principles of the HBBM-birth of Met in the past along with its evolution are firmly established while the hypotheses regarding the instantaneous and uniform creation of matter evidently need revision. In the proposed model an inhomogeneous transition of compact space in loose 3-dimensional space (decompactification-DC) with appropriate creation of matter is a factor which determines the evolution of Met. The "elasticity" of space is a driving force of the DC. The DC starts in a single causally connected domain and develops in oscillating quasi-solitons, which are observed as quasars and active galactic nuclei (AGNs). The particle horizon coincides with the event horizon and has temperature 3 K.

Session 53: SNs, Planetaries and Circumstellar Disks
Display Session, 10:00am-6:30pm
Atlas Ballroom

53.01

An Atlas of Line-resolved Images of ASCA Supernova Remnants

E. V. Gotthelf (NASA/GSFC/USRA)

We present examples from a forthcoming atlas of narrow-band X-ray images of supernova remnants (SNR) obtained with the ASCA observatory. These ASCA images map SNRs in several energy bands between 1-10 keV and provide the first maps in the energy band above 4 keV and in individually resolved emission lines and continuum features. Recent studies of the bright SNRs Cas-A and Tycho reveal complex spatial morphologies in various line emission bands and allow the elemental abundances and temperature distribution to be mapped out across the remnants. We concentrate on Galactic SNRs which are resolved by the ASCA telescope. Here, we summarize the current ASCA observations, and demonstrate the techniques used to create the exposure-corrected line-resolved maps from single and multiple observations of SNRs, for all four imaging instruments aboard ASCA.

53.02

Gamma Ray Emission from the Vicinity of the Supernova Remnant G312.4-0.4

G. L. Case, D. Bhattacharya (U. C. Riverside)

We discuss the excess gamma ray emission seen from the regions adjacent to the supernova remnant (SNR) G312.4-0.4 in the energy range of 100 MeV to 10 GeV with the EGRET instrument on board the Compton Gamma Ray Observatory. 2EG J1412-6211, which was originally discovered by COS-B (catalog name 2CG 311), is located 0.4 deg. southwest from the center of the radio shell remnant G312.4-0.4. Its connection with the SNR is discussed. Another EGRET source, 2EGS J1418-6049, lies 1.1 deg. northeast from the center of G312.4-0.4. This source coincides with a non-thermal radio source at 843 MHz and a hard x-ray source. Its spectrum extends out to GeV energies. We argue that 2EGS J1418-6049 is transient in nature. Its variablilty makes it unlikely that 2EGS J1418-6049 is associated with G312.4-0.4 or any other SNR or pulsar as suggested by Roberts and Romani (1998).

53.03

Kinematics of the Young, Oxygen-Rich Supernova Remnant G292.0+1.8

B. J. Walldroff, P. F. Winkler (Middlebury College), J. A. Morse (U. Colorado)

We have used the imaging Fabry-Perot spectrometer on the 1.5m telescope at CTIO to map the velocity structure of [O III] λ5007 emission from the young supernova remnant (SNR) G292.0+1.8. This is one of only three Galactic oxygen-rich (Cas A type) SNRs, all of which have filaments showing strong oxygen lines, essentially zero hydrogen, and velocities $\gtrsim$ 1000 km s^{-1}. These filaments are almost surely shards of ejecta from the core of a massive star, which remain uncontaminated by interaction with the interstellar medium. Since the filaments have probably decelerated little if at all since being launched by the supernova event, their radial velocities are proportional to their distances (from the explosion center) along the line of sight. Therefore, taking slices in velocity space enables us to construct a three-dimensional map of the remnant. We will report our results for the kinematics and distribution of [O III]-emitting filaments in G292, and compare these with emission observed in other bands.

This work has been supported by the NSF through grant AST-9618465 and by the W.M. Keck Foundation through the Keck Northeast Astronomy Consortium.

53.04

Hubble Space Telescope/WFPC2 Images of Four Nova Shells

F. A. Ringwald, R. A. Wade, J. A. Orosz, R. B. Ciardullo (PSU)

We present initial results from a snapshot survey, taken with Hubble Space Telescope's Wide-Field/Planetary Camera 2 (WFPC2), of the gaseous shells of classical novae that erupted since 1980. The images were taken through narrow-band filters, in the light of Halpha, [N II] 6583, and [O III] 5007. Nova shells evolve over years to decades, in contrast to 10^4 years for planetary nebulae. We therefore intend for this survey to be first-epoch observations of a long-term survey, to observe the hydrodynamics of nova shells unfolding before our very eyes.

We discover three new shells, around CP Cru (Nova Cru 1996), V1425 Aql (Nova Aql 1995), and V351 Pup (Nova Pup 1991), and clearly resolve another, around QU Vul (Nova Vul 1984 #2). The V351 Pup and QU Vul shells appear as rings, although the hollow insides may be due to the filter response. Still, QU Vul shows definite structure in its 1.5-arcsecond diameter ring. The [O III] image of V1425 Aql may show bipolar structure: if so, the lobes are only 0.2 arcseconds apart.

This work was supported by STScI grant GO-07386.

53.05

Spatially Resolved X-ray Spectroscopy of the Supernova Remnant G296.1-0.7

K. A. Flanagan (MIT Center for Space Research), U. Hwang (NASA/GSFC), C. R. Canizares, T. H. Markert (MIT Center for Space Research)

We report the preliminary results of our analysis of ASCA X-ray observations of G296.1-0.7, a bright Galactic supernova remnant with an unusual morphology (a nearly complete ring with an extension to the southwest). Our previous observation with the ROSAT PSPC showed evidence of relatively slight but statistically significant variations in the spectrum across the remnant. We detail our study of spatial variations in the X-ray spectrum of the remnant, including non-equilibrium ionization fits to the spectra.

53.06

Identifying Shock Structures in Supernova Remnants

Barron Koralesky, L. Rudnick (U of MN), W. M. Goss, D. A. Frail, M. J. Claussen (NRAO/AOC), R. Petre, E. V. Gotthelf, J. W. Keohane (NASA/GSFC), M.C.H. Wright (U of C, Berkeley), John R. Dickel (U of IL, U-C), A. J. Green (U. of Sydney)

Using observations and theory, we have attempted to identify and quantify shock structures in young and intermediate aged SNRs. This poster outlines several studies currently underway to study these shocks. By comparing measurements to simulations we have developed a method to classify a remnant's dynamical age according to the classical stages of free expansion through the Sedov-Taylor phase. We have found both Cas A and Kepler's SNRs to be in the intermediary phase between free expansion and Sedov-Taylor. We have utilized OH(1720) masers as a tool to find shock positions and to prove SNR-molecular cloud interactions. These masers have also allowed us to measure milliGauss magnetic fields in the shocks of two remnants. We have found spectral index variations in Cas A over a large range of frequency, which is consistent with many power-law distributions of electron energies. Preliminary expansion measurements of Cas A in the x-ray will also be presented, which will help define shock structures in this remnant.

SNR research at the University of Minnesota is supported by the NASA Graduate Research Program and the National Science Foundation under grant AST 96-19438.

53.07

The RXTE X-Ray Spectrum of SN 1006 and the Implications for Cosmic-Ray Acceleration

G. E. Allen, R. Petre, E. V. Gotthelf (NASA/GSFC)

We present the RXTE high-energy X-ray spectrum of the supernova remnant SN 1006. The results of an analysis of the RXTE and ASCA data of this remnant support a previous report that the high-energy X-ray spectrum of the shell is dominated by synchrotron radiation from electrons that have been accelerated to energies as high as $\sim$ 100 TeV. Furthermore, the results show that the non-thermal X-ray spectrum steepens with increasing energy as is expected for synchrotron emission. The recent detection of gamma rays at energies $>$ 3 TeV from SN 1006 confirms that this remnant contains electrons that have been accelerated to very-high energies. While X-ray emission is observed from both the north-east and south-west rims of the remnant, no gamma-ray emission is observed from the south-west rim. We show that the RXTE X-ray data may or may not be consistent with the upper limit on the gamma-ray flux of the south-west rim. We review the radio through gamma-ray spectrum and discuss the implications of the data for Galactic cosmic-ray acceleration.

53.08

Prospects for Detailed Line Spectroscopy of the SNR in the Magellanic Clouds

J. Spodek, S. Kahn, A. Rasmussen (Columbia University)

We present simulations of the Magellanic Cloud SNR sample from XMM's fully detailed raytrace, demonstrating its capabilities in detailed line spectroscopy of sources of moderate spatial extent. The MC sample includes a range of SNR types, ages, and nonequilibrium ionization stages in a well-known environment that reduces observational uncertainties. Detailed line spectroscopy, possible only with the new generation of X-ray telescopes, of the 0.5–2.0 keV band will provide a wealth of previously unavailable data. This band, which is rich in lines of K shell Ne, Mg, and Si, and L shell Fe, contains powerful diagnostics to constrain plasma uncertainties. The high dispersion of XMM's reflection grating spectrometer makes it the ideal tool for studying moderately extended (10–100 arcsec) remnants.

53.09

V and R Magnitudes for Planetary Nebula Central Stars in the MACHO Project Galactic Bulge Fields

J. Lutz (WSU), D. Alves (LLNL), A. Becker (UW), T. Vandehei, K. Griest (UCSD), M. Lehner (Sheffield), C. Alcock, K. Cook, S. Marshall, D. Minniti (LLNL), R. Allsman, K. Freeman, B. Peterson, A. Rodgers (MSSSO), M. Pratt (MIT), C. Stubbs, A. B. Tomaney (UW), D. Bennett (Notre Dame), P. Quinn (ESO), W. Sutherland (Oxford), D. Welch (McMaster)

The MACHO Project has been monitoring selected fields in the galactic bulge since 1992. About 35 planetary nebulae (PN) with observable central stars are located within these fields. These PN are well worth investigating both for improvements in magnitude measurements and especially to check the possibility of variability. This is a preliminary report on data for 22 of the PN central stars. Cousins V and R magnitudes were measured for each of the stars; the V magnitudes range from 13.47 to 18.20. The quality of the photometry and problems encountered with reducing the data (e.g. objects near the edge of a field, cosmic ray hits) will be discussed as part of our paper. One central star, that of the PN Hf 2-2 (MACHO ID 139.32591.211), appears to be variable with a period of 0.398571 days.

53.10

A Search for Radio SNRs in the Irregular Galaxies NGC 4449 and IC 1613

C. K. Lacey (Univ. Nacional Autonoma Mexico), W. M. Goss (NRAO), N. Duric (U. of New Mexico), M. Rosado, M. Valdez (Univ. Nacional Autonoma Mexico)

A recent VLA survey of two irregular galaxies resulted in the identification of 20 compact radio sources in NGC 4449 at 20 and 6 cm and 11 sources in IC 1613 at 6 cm. Flux densities and positions are presented along with the spectral indices for the radio sources in NGC 4449. The sample of compact radio sources in NGC 4449 is separated into supernova remnant and HII region candidates based on the spectral index. Both NGC 4449 and IC 1613 each have a previously detected radio supernova remnant. The flux densities of these supernova remnants obtained in this survey are compared to previously published values. Additionally, the radio images are compared with their respective Hα images which were taken at the National Astronomical Observatory in San Pedro Martir. The association of star formation regions and the radio sources is examined. The candidate supernova remnants in NGC 4449, a Magellanic irregular, are compared to a sample of 37 radio supernova remnants identified in the nearby spiral NGC 6946.

53.11

Detections and Characteristics of Supernova Remnants in Eight Nearby Spiral and Irregular Galaxies

T. G. Pannuti, N. Duric (University of New Mexico)

We have conducted a multi-wavelength (X-ray, radio and optical) survey for supernova remnants (SNRs) in eight nearby spiral and irregular galaxies: NGC 247, NGC 300, NGC 2403, NGC 4449, NGC 5236 (M83), NGC 6946, NGC 7793 and IC 1613. Our own VLA radio observations have been examined in conjunction with archived ROSAT images (made with the PSPC and HRI instruments) and published optical data to search for SNRs in these galaxies. In addition to detecting SNRs, we have also examine dother characteristcs of these sources, including spectral energy distributions over all three wavelength domains and possible coincidences with historical supernovae (SNe) in these galaxies. Initial results and tentative conclusions are presented.

53.12

An Evaluation of the Richtmeyer-Meshkov Instability in Supernova Remnant Formation

R. P. Drake (U. Michigan), J. Kane (U. Arizona), B. A. Remington (LLNL)

We present an initial evaluation of the role of the Richtmeyer-Meshkov (RM) instability in supernova remnant (SNR) formation. Although the Rayleigh-Taylor (RT) instability is most often considered in the canonical account of SNR formation, the theoretical penetration depths for the RM instability suggest that it could play a more significant role, particularly in the early stages. Here we present and discuss theory and simulations to evaluate this possibility. We apply some recent theory of RM to the SNR case to show that it is plausible that RM could play a significant role. One must note, however, that in some key respects the SNR system does not satisfy the assumptions used in such theory. This motivates simulations. Accordingly, we have used the code PROMETHEUS to perform a sequence of 2D hydrodynamic simulations in order to test this possibility. Our choice of parameters corresponded to typical Type Ia conditions and is motivated by the work of Jun and Norman [ApJ 465: 800 1996], which we reproduced for the same initial conditions. We have explored a variety of initial conditions, with various perturbed interfaces to seed RM and with or without fluctuations to seed RT. Here we discuss in detail a case in which we impose a severe RM perturbation in the expanding ejecta behind the reverse shock. The perturbation produces significant early RM growth, with spikes penetrating from the contact surface to the forward shock. Then the RM instability weakens, RT growth eventually dominates, and the perturbation of the

forward shock diminishes. We conclude that the RM instability of a single perturbation is unlikely to account for the observed radio and x-ray structures which extend to the forward shock. We speculate that the RM instability might account for such observations if it is continuously reseeded.

53.13

Molecular Gas Associated with Wolf-Rayet Ring Nebulae

J. Welzmiller, A. P. Marston (Drake University), J. Black (Onsala Space Observatory, Sweden)

A crucial parameter in determining the evolution of massive stars is the amount of mass lost through stellar winds. Over the lifetimes of stars with initial masses greater than $25M_{\odot}$, it is expected that mass loss will occur in several stages, in a fast wind during an early O star phase, in a slow wind in an intermediate red supergiant phase (or via eruptions in a Luminous Blue Variable phase) and then during a second fast wind phase when the star enters a Wolf-Rayet phase. Evidence of the mass-loss can be seen in the circumstellar regions of these stars in the form of ring nebulae. Here we present the first CO 1 − >0 emission-line maps of the vicinities of two Wolf-Rayet stars (WR16 and WR75) and their associated ring nebulae. We illustrate that significant amounts of molecular gas appear associated with these ring nebulae and therefore that the mass of gas in ring nebulae is significantly higher than inferred from observations of the ionized gas component. We discuss the possible stellar and interstellar origins of these molecular materials and the implications for the evolution of massive stars up to the Wolf-Rayet phase.

This work was funded in part by NASA JOVE grant NAG8-264, NASA ADP grant NAG5-2999 and a grant from NASA administered by the American Astronomical Society.

53.14

Imaging and Kinematics of Multiple Ring Nebulae Around Wolf-Rayet Stars in M33

A. P. Marston (Drake University), L. Drissen (U. Laval, Canada)

The study of circumstellar materials around evolved massive stars leads to the possibility of obtaining information on the history of such stars. In particular, Wolf-Rayet stars are believed to have evolved from massive ($> 25M_{\odot}$) O star progenitors via a phase of major mass loss (such as a red supergiant or luminous blue variable). The morphology and kinematics of ejected materials may be expected to provide information on the amount of and timescale for mass-loss. In particular, the existence of multiple shells around Wolf-Rayet stars enables the study of the effects of different phases of mass loss. We present high resolution optical imaging and Fabry-Perot observations, made at the Canada-France-Hawaii Telescope (CFHT), of multiple ring nebulae around Wolf-Rayet in the nearby galaxy M33. Our results show: (i) The existence of ejecta shells inside of main sequence shells O star cavities, some of which are almost the same size as the cavities, suggesting ejecta expansion is not necessarily stalled by the hot interior of the progenitor O star bubble. (ii) Hα and [OIII] shell kinematics are often dramatically different with [OIII] emission almost exclusively associated with fast-moving Wolf-Rayet wind-blown bubbles inside ejecta materials. (iii) Expanding bubbles of [OIII] emission appear around WN rather than WC subclasses of Wolf-Rayet stars, suggesting "blowouts" of the Wolf-Rayet blown winds towards the end of the WN phase and prior to the WC phase. (iv) Nebulae associated with WC stars are larger than those associated with WN stars, which is consistent with the evolution of Wolf-Rayet stars from WN to WC subtype.

This work was supported in part by a NASA ADP grant NAG5-2999 and by a grant from NASA administered by the American Astronomical Society.

53.15

Observations of CO Isotopes in Planetary Nebulae

D. S. Balser, J. P. McMullin (NRAO), T. L. Wilson (MPIfR, SMTO)

Measurements of the carbon isotopic ratio, $^{12}CO/^{13}CO$, in several planetary nebulae (PNe) have been determined by observing the millimeter and sub-millimeter transitions of CO with the NRAO 12m and SMTO 10m telescopes. These data help constrain mixing theories in stellar evolution models and provide a connection between similar measurements in red giant branch stars and the interstellar medium.

53.16

OH 1720 MHz Masers in Supernova Remnants — C-Shock Indicators

P. Lockett (Centre College), E. Gauthier (Johns Hopkins University), M. Elitzur (U.Kentucky)

Recent observations have shown that the OH 1720 MHz maser is a powerful probe of the shocked region where a supernova remnant strikes a molecular cloud. We have performed a thorough study of the pumping of this maser and have found tight constraints on the physical conditions needed for its production. The presence of the maser implies low temperatures (50–150 K), low molecular densities ($\sim 10^5 cm^{-3}$) and OH column densities of the order of $10^{16} cm^{-2}$. We show that these conditions can exist only if the shocks are of C-type, thus the presence of this maser is a powerful shock diagnostic. These conditions also mean that the 1720 maser will be inherently weak compared to the other ground state OH masers. All the model predictions are in good agreement with the observations.

53.17

Extended X−ray Emission from the Planetary Nebulae BD+303639

D. Leahy, S. Kwok, D. Yin (U. Calgary)

We report discovery of extended X–ray emission from the planetary nebulae BD+303639. BD+303639 was the target of a *ROSAT HRI* observation with the goal of resolving the x–ray emission. Analysis of the *ROSAT HRI* image shows clearly that BD+303639 has extended x-ray emission which can be fit with a Gaussian with a σ of 2.6 arcseconds (after correction for the *HRI* point spread function). This size is the same as that of the optical nebulae, as recently imaged in HST observations.

53.18

The X-ray Properties of SNRs in Diffuse Media

R. L. Shelton (NASA/Goddard Space Flight Center)

Supernova explosions in very tenuous medium are important in many contexts such as the lower Galactic halo, the Local Bubble, and external galaxies. This poster presents the X-ray properties of a simulated supernova remnant (SNR) evolving in a diffuse medium and applies the results to SNRs in the lower Galactic halo.

I present very high resolution spectra, diagrams of the spatial appearance, and estimates for the ROSAT PSPC count rates at various ages in the remnant's life. The X-ray emitting gas is out of collisional equilibrium — in the young remnant, the gas is dramatically underionized and later it is noticeably overionized. As a result, the remnant has a ROSAT PSPC R1/R2 color temperature of $\sim 10^6$ K during its X-ray bright phase and a slightly lower color temperature thereafter.

Given the progenitor statistics and the duration of the X-ray bright phase in the SNR's evolution, the lower halo in each Galactic hemisphere should contain approximately 1 X-ray bright SNR at any given time. X-ray bright SNRs should cover roughly 1% of the halo and provide hundreds to thou-

sands of ROSAT 1/4 KeV counts s^{-1} $arcmin^{-2}$. Maps of the halo emission in the south show a couple of bright patches and a dimmer, mottly background. The halo SNRs have the potential to explain a couple of the bright patches seen in the south, while other mechanisms are required to explain the additional more widespread but dimmer emission.

53.19

HST Imagery and Temperature Fluctuations for the PN NGC 6818

Robert H. Rubin (NASA/Ames, Orion Enterprises), Reginald J. Dufour, Matt Browning (Rice University), J. Patrick Harrington (U. of Maryland)

We present new HST/WFPC2 imagery for the planetary nebula (PN) NGC 6818. Observations were made in line filters F437N, F487N, F502N, and F656N plus continuum filter F547M. The primary goal was to develop a high spatial resolution ($\sim 0.1''$) map of the intrinsic line ratio [O III] 4363/5007 and thereby evaluate the electron temperature (T_e) and the mean-square T_e variation (t^2) across the PN. In this process we developed an extinction map from the F487N (Hβ) and F656N (Hα) images by comparing the observed line ratios in each pixel to the theoretical ratio and computing a c(Hβ) map which was used to correct the observed 4363/5007 ratios for reddening. We also adjust for the continuum contribution to the line filter data. We present color-coded pictures of the reddening (c(Hβ)) map, the [O III] T_e map, as well as our determinations of t^2. The T_e map shows a decline from $\sim$ 14000 K in the inner regions to $\sim$ 11000 K at the outer edge. Such a radial T_e gradient is expected for a high-excitation nebula with a prominent He^{++} zone such as NGC 6818.

A composite of images taken in 3 filters (F656N, red; F487N, blue; and F502N, [O III] 5007, green) shows a roughly spherical outer envelope as well as a brighter vase-shaped interior "bubble." There is a prominent orifice to the North and a smaller one to the South, along the major axis, possibly caused by a blow-out from a fast wind. This nebula has an appearance remarkably similar to that of the PN NGC 3918 previously imaged with HST by H. Bond.

We note from the continuum images (F547M) two stars in the nebular field that are fainter than the prominent central star; these are roughly 2–4″ N and NE of the central star. Further study is needed to establish whether or not there may be a physical association of either star with the central star.

Supported by AURA/STScI grant related to GO-6792.

53.20

Models of Main Sequence Circumstellar Disks Based on IRAS SEDs and Angular Sizes

D. B. Dahari, D. E. Backman (Franklin and Marshall College)

Many nearby otherwise normal main sequence stars have far-IR excesses attributable to orbiting circumstellar grains. It is clear that the grains must be second-generation grains released from larger parent bodies such as asteroids or comets because the grain lifetimes are much shorter than the system ages. In the well-known prototypes α Lyr, α Piscis Australis, β Pictoris and ϵ Eridani, the circumstellar disks appear to be comparable in scale to the Kuiper Belt of our solar system and to contain relatively empty central regions with sizes similar to the planetary zone of our system.

We present new models for the 4 prototype disks and 6 other systems using the best available information on the far-IR angular sizes plus spectral energy distributions from IRAS and other photometric data. Our analyses of the source sizes include convolution of source models with IRAS diffraction functions and detector spatial response maps.

The general trends seen in the prototypes extend to the fainter systems: grains smaller than 100 μm lying a few 10s to 100s of AU from the central stars, with optical depths more than 10^2 times that of our system's zodiacal cloud, and with deficits of warm emission implying significant central low-density regions.

53.21

A Circumstellar Disk around HR 4796

David W. Koerner (U. Pennsylvania), Dana Backman (Franklin & Marshall College), Michael Ressler, Michael Werner (JPL)

We report the discovery of a circumstellar disk around the young A0 star, HR 4796, in thermal infrared images obtained at the Keck telescope. The disk appears nearly edge on at $\lambda = 20.8\mu$m, with diameter $\sim 3''$ (corresponding to R$\sim$ 200 AU at the 67 pc distance of HR 4796) and long axis at PA $\sim$ 30°. The intensity of emission does not decrease monotonically with radius but *increases* outward from the star and peaks near both edges. This appearance accords well with previous interpretations of the spectral energy distribution from which the presence of a solar-system-sized hole in the disk is inferred, perhaps cleared out by processes associated with planet formation. We refine estimates of the size of the hole with the aid of simulated images generated by a simple model of the disk emission and confirm its size as being very similar to that of the region enclosed by the inner edge of our own Kuiper belt. With an age of 10 Myr, HR 4796 may possess a disk in a transitional planet-forming stage between that of a truly proto-planetary disk, as perhaps exemplified by the molecular gas around the Herbig Ae star MWC 480, and more tenuous debris disks like that detected around the much older (100 Myr) A0 star, Vega.

Session 54: Star Clusters, Kinematics and the Galactic Center
Display Session, 10:00am-6:30pm
Atlas Ballroom

54.01

A Complete Sample of Hot UV-Bright Stars in Globular Clusters

W. Landsman (Raytheon STX), S. Moehler, R. Napiwotzki (U. Erlangen-Nurnberg), T.Stecher (NASA/GSFC)

We present preliminary results of our program to obtain optical and ultraviolet spectra of all UV-bright objects discovered on wide-field (40′) ultraviolet images of fourteen globular clusters observed with the Ultraviolet Imaging Telescope (UIT). The star M4-Y453 (Teff = 59,000 K, log g = 5.2) is the hottest post-AGB star without a planetary nebula yet found in a globular cluster. A STIS low-resolution ultraviolet spectrum of NGC 6723 - III60 (Teff = 40,000 K, log g = 5.2) shows a large overabundance of nitrogen. The sdO stars in globular clusters can be classified as either post-EHB (extreme horizontal branch) stars with strong helium depletions, or as post-AGB stars with approximately solar helium abundances.

54.02

The Age of the Globular Cluster NGC 6652 from WFPC2 Imaging

Brian Chaboyer (Steward Obs.), T. Armandroff (KPNO), A. Sarajedini (San Francisco State U.)

Images of the inner halo globular cluster NGC 6652 have been obtained with WFPC2 on HST. These images have been used to derive a V,V-I color magnitude diagram (CMD) for this moderately metal-rich cluster. The CMD clearly delineates the principal sequences of this cluster, from the upper giant branch to $\sim$ 4 magnitudes below the main sequence turn-off. The reddening, metallicity and distance of NGC 6652 are derived from the CMD. Using a new set of α-element enhanced isochrones, the age of NGC 6652 is derived using ΔV(TO − HB), Δ(V − I) and isochrone fitting. This age is compared to ages of other globular clusters in order to further our understanding of the formation of the inner galactic halo.

54.03

Hubble Space Telescope Imaging of Globular Clusters in the Fornax Cluster

Carl J. Grillmair (SIRTF Science Center, Caltech), Duncan A. Forbes (U. Birmingham), Jean Brodie (Lick Obs.), Rebecca Elson (U. Cambridge)

We examine the distribution of globular clusters over luminosity and $B - I$ color for three early-type galaxies in the Fornax cluster using imaging data from the Wide Field/Planetary Camera 2 on the Hubble Space Telescope. The luminosity functions we derive are in most cases better than 50% complete down to B = 26.5. We find that both the luminosity functions and color distributions of globular clusters in NGC 1399 and NGC 1404 are virtually indistinguishable. The metallicity distribution function, as inferred from the color distributions in these two galaxies, is similar to or even broader than that of M 87. The objects detected around NGC 1316 are considerably bluer and fainter on average than the globulars associated with NGC 1399, and their distribution over magnitude appears to be more consistent with that of an open cluster luminosity function. The number of unresolved objects we find at a distance of 440 kpc from NGC 1399 is consistent with nothing more than compact background galaxies, though the small field of view of the WFPC2 does not allow us to put strong constraints on the number of intergalactic globular clusters.

54.04

Optical Spectroscopy of Globular Clusters in M81 with the W. M. Keck Telescope

L. L. Schroder, J. P. Brodie (UCO/Lick Obs.)

We present high S/N optical spectra of a small sample of globular clusters in the spiral galaxy M81. We present line strength indices on the Lick IDS system and compare them with those for Milky Way and M31 globular clusters. We combine velocity data of our sample with velocities from a previously studied sample of M81 globular clusters and present a brief kinematic analysis of the M81 globular cluster system.

54.05

Multiplicity Survey of Alpha Persei: Studying the Effects and Evolution of Companions

J. Patience, A. M. Ghez (UCLA), I. N. Reid, K. Matthews (Caltech)

In order to investigate the large discrepancy between the companion star fraction (csf) of young T Tauri stars and older field stars and to study the role of binarity in stellar rotational evolution, we have conducted a 2.2 μm speckle imaging survey of 106 members of the young (50-70 Myr) open cluster α Persei. The stars in the sample all have K magnitudes brighter than K=10.0mag. Based on a preliminary analysis of this data set, 10 binaries are detected within the separation range 0.″20 to 1.″70 (33 AU - 282 AU) and the magnitude difference range $\Delta K \leqslant 3$mag; the limited number of binaries detected thus far prevents a significant comparison of the csf of the slow and rapid rotators in α Persei. The initial assesment of the observed csf is $csf_{\alpha Per}$=0.09±0.03. This value of the cluster multiplicity is more than 2 times lower than the observed csf, measured over the same separation range, for nearby T Tauri stars (csf_{TT}=0.24±0.03), but is consistent with the results from surveys of the slightly older (~125 Myr) Pleiades cluster (csf_{Pl}=0.13±0.03) and the much older (~5 Gyr) field G-dwarfs (csf_{field}=0.13±0.03). Contrary to the results of a recent speckle survey of the Hyades (sensitive to a closer separation range), the initial results of the α Persei study do not support the idea that multiple systems are disrupted over time, and instead support explanations for the high value of csf_{TT} that involve environmental factors such as density and temperature or different distributions of binary separations. Further analysis of the α Persei data will cover a wider separation range, allowing an investigation of the distribution of binary separations.

54.06

On the Identification of New Low-mass Members of the Alpha Persei Cluster and Rotation Periods of Open Cluster Stars

C. F. Prosser (NOAO)

A review is given of the photometric/spectroscopic examination of possible optical counterparts to more than 200 ROSAT X-ray sources in the region of the α Persei open cluster resulting from the analysis of two X-ray datasets: (a) a raster survey (Prosser & Randich 1997 [Center for Astrophysics (CfA) Preprint 4537]) and (b) three 22−25 ksec ROSAT PSPC pointings (Prosser, Randich & Simon 1997 [CfA Preprint 4538]). CCD photometry is employed to obtain magnitudes and colors for stars/objects close to the X-ray positions, with additional echelle and low-dispersion Hα spectra provided for some stars.

In the raster survey, of 73 X-ray sources not matched to catalogued stars, ~40 have an optical counterpart with photometry acceptable for cluster membership and ~20 of these also have radial velocities consistent with membership. In the PSPC pointings, for almost 60 X-ray sources a photometric candidate member is identified, some of which can be excluded from membership on the basis of discrepant radial velocity or X-ray characteristics. On the order of 30 new members or likely members have been identified from the PSPC pointings based on available data. We discuss the X-ray properties of these potential new members and why they may not have been identified in earlier membership surveys.

Additionally, photometric rotation periods of open cluster stars have been reported by Prosser & Grankin 1997 [CfA Preprint 4539]. Several members of the α Persei cluster have been monitored and the corresponding relation between coronal X-ray activity and rotation period derived. The relation among mid-G/K type members illustrates both the previously noticed downturn in L_X/L_{bol} at high rotation rates and the sharp decrease in coronal activity at long rotation periods as seen among Pleiades stars. Intensive observation of one slowly rotating G-type member of IC4665 has enabled a period determination of 8−10 days to be made and illustrates the need for (and limitations of) high quality observations.

54.07

Mu Leo and the Metal-Rich, Old Open Cluster NGC 6791

R. C. Peterson (UCO/Lick), E. M. Green (Steward/UofA)

The old open cluster NGC 6791 is metal-rich, yet harbors a variety of blue horizontal branch (BHB) stars. Analysis of an echelle spectrum of the coolest BHB star confirms that the cluster metallicity is high, [Fe/H] = +0.4 ±0.1, more than twice solar (Peterson & Green, ApJL, submitted). To explore its HB population further, we obtained moderate S/N echelle spectra at Lick Observatory of over two dozen RHB candidates for radial-velocity confirmation of membership. These were combined to form a single composite spectrum representative of the typical cluster RHB star. A direct comparison of this composite spectrum with an existing echelle spectrum of the prototypical super-metal-rich field red giant Mu Leo shows that the two spectra are nearly indistinguishable. This is surprising, since analyses of Mu Leo have yielded for decades a temperature cooler by 300K or more and a surface gravity 0.5 lower for the star, resulting in a somewhat lower metallicity. A check by Grenon of recent HIPPARCOS data for Mu Leo confirms that its absolute magnitude is Mv = +0.84 ± 0.08 and its color is B-V =1.222; both are consistent with the NGC 6791 RHB upon adoption of a reddening E(B-V) = 0.14±0.03, at the low end of the range of current determinations. We will discuss in detail the nature and limitations of this similarity, and its consequences for cluster reddening and distance. We will also comment on the ramification that our own and others' analyses of cool giants as strong-lined as these are much less reliable than previously believed.

54.08

The Reality of the Stars Found Below the Horizontal Branch in M 92

A. G. Davis Philip (ISO and Union College)

In previous reports the detection of blue stars falling below the horizontal branch in M 92 has been described. At DAO a check was made of three individual CCD investigations of M 92. The first was the data set obtained by me at KPNO; the second was a CCD investigation by Sarajedini; and the

third was a CCD investigation by Stetson. DAOMATCH and DAOMASTER were used to cross-identify stars on all the frames, identified by the star number on the KPNO frames. The stars falling below the horizontal branch were identified in all data sets and they were found to have the same characteristics, namely blue colors and magnitudes 0.4 mag or more below the horizontal branch. These data confirm the reality of their positions below the horizontal branch. Their positions are not the result of photometric errors.

54.09

Magnetic Flux Accumulation at the Galactic Center and its Implications for the Strength of the Pre-Galactic Magnetic Field

B. D. G. Chandran, S. C. Cowley, M. Morris (UCLA)

We study the inflow of disk gas towards the Galactic center during the lifetime of the Galaxy and its effect on magnetic field lines frozen-in to the interstellar plasma. While compression leads to a large amplification of the "vertical" magnetic field (pointing perpendicular to the disk), ambipolar diffusion efficiently removes from the disk magnetic flux components oriented parallel to the Galactic plane. Contrary to some previous studies, we argue that turbulent diffusion is not effective at removing flux from the disk. On the other hand, we argue that turbulent interchange motions of nearly parallel vertical field lines at the Galactic center enhance the efficiency of magnetic reconnection of neighboring regions of oppositely directed vertical field. This argument suggests that the sign of the present-day vertical field at the Galactic center is uniform. If the Galactic-center field originates in the entrainment of a pre-Galactic field B_0 in radially inflowing interstellar plasma, then observations of the vertical flux through the central 200 pc of our Galaxy yield a measure of the pre-Galactic field that depends on the total mass accreted into the central 200 pc during the Galaxy's lifetime. If this mass is $3 \times 10^9 M_\odot$, and if the surface density of disk gas is roughly constant over the lifetime of the Galaxy, then $B_0 \gtrsim 2 \times 10^{-7}$ G, regardless of the angle of the pre-Galactic field with respect to the Galactic plane. The abundance of mechanisms for radial accretion of disk gas suggests that strong magnetic fields should be a generic feature of the centers of spiral galaxies. We also note that cosmic-ray confinement in the strong vertical field at the Galactic center is poor.

54.10

The Galactic Center Radio Threads: A Multi-Frequency, Polarimetric Study

C. C. Lang, M. Morris, L. Echevarria (UCLA)

Multifrequency, polarimetric observations were made with the VLA of two of the Galactic Center non-thermal radio filaments, G0.08+0.15, and G359.96+0.09, also known as the Northern and Southern Threads (Morris & Yusef-Zadeh, 1985). Observations were made at 20, 6, 3.6 and 2 cm and had high enough resolution to resolve the Threads for the first time. The 20 em image reveals a wealth of new detail in sources within the inner 60 pc of the Galaxy. The Southern Thread shows a significant split along its length, similar to what has been observed in the G359.54+0.018 filament (Yusef-Zadeh *et al.* 1997). With a resolution of 2′, the 6 cm image reveals little substructure along its length, although there is a gradual broadening along its length and it becomes markedly diffuse at its NE extent. The spectrum of the Northern Thread has been fit with two components, $\alpha = -0.7$, and $\alpha = -2.0$, where $S_\nu \propto \nu^\alpha$. The spectral index does not vary signigicantly along its length, which prevents us from locating the source of the acceleration of the electrons. Polarization measures at 6 and 3.6 cm confirm that the Northern Thread is non-thermal. The fractional polarization in the NTF is as high as 50% in some regions, although the polarized emission has a very patchy distribution. The RM varies irregularly across the filament, and its value ranges from 200-3000 rad m^{-2}. The lack of any apparent pattern in the distribution of RM suggests that the Faraday rotating medium is not intimately assocated with the filament since it is so highly ordered. The Faraday corrected polarization vectors reveal that the intrinsic magnetic field direction of the Northern Thread is predominantely aligned along its long axis. At 6 and 3.6 cm, the total intensity of the Southern Thread does not stand out, but the polarized emission at 3.6 cm has been imaged and shows that the NTF is bifurcated, similar to the substructure seen at 20 cm.

54.11

Spectroscopic Studies of Microlensed Sources Towards the Galactic Bulge

S. Kane, K. Sahu (STScI)

The spectroscopy of microlensed sources towards the galactic bulge may be used as a tool for studying, among other things, the kinematics and extinction effects of the Galactic bulge, and the contributions of the bulge and the disk lenses to the microlensing optical depth. We have obtained spectra of about 25 such microlensed sources using the 3.6m ESO telescope + EFOSC covering the wavelength region 3900 to 7000 A. Many of the sources were observed during the microlensing, which would have otherwise been too faint to be observed. The first results of this study will be presented.

54.12

Metallicity Dependent Kinematics of F Stars from HIPPARCOS Data

A. Suchkov, M. McMaster (STScI)

We use HIPPARCOS data and available radial velocities for *uvby* F stars within 125 pc to study the relationship between kinematics and metallicity of luminosity groups of F stars in different temperature ranges. We find a clear-cut correlation between kinematics and metallicity which is, however, distinctly different for different luminosity and temperature ranges. Interpretation of those correlations in terms of history of star formation and metal enrichment in the local galactic disk infers that both metallicity and kinematics range broadly at any given age. However, if combined with and complemented by luminosity and temperature information, kinematics and metallicity provide a tool to disintangle even subtle evolutionary effects in the galactic disk.

54.13

The hk,(b-y) Metallicity Calibration for Metal-Poor Red Giants

B. J. Anthony-Twarog, B. A. Twarog (U. Kansas)

We have used uvbyCa photometry for evolved stars of solar metallicity and lower abundance, together with spectroscopic abundance data on a homogeneous merged scale to recalibrate the hk,(b-y) photometric plane. Isometallicity lines have been constructed over the [Fe/H] range from −1.0 to −3.4 from 122 stars. Comparison of Hipparcos distances to our photometric distances, used to establish appropriate reddening corrections, shows good agreement. The dispersion of photometric metallicity estimates is less than 0.17 dex for the more metal-deficient portion of the sample.

Session 55: New Digital Sky Surveys
Display Session, 10:00am-6:30pm
Atlas Ballroom

55.01

GSC-II: An Overview of the Database System

G. Greene, B. McLean (STScI), A. Volpicelli (OATo)

The Catalogs and Surveys Branch of the Space Telescope Science Institute, in collaboration with a number of other institutions, is constructing an all-sky catalog of astronomical objects to support the operations of current and future ground and space based telescopes. It is being generated from the application of image processing and object recognition techniques to digitized photographs taken from the Palomar and UK Schmidt survey telescopes. To accurately calibrate these data, it is crucial that we be able to support cross-references between the internal observations and to other external astronomical databases. This database is expected to contain about 15 billion measurements of 2 billion individual stars and galaxies, and will be about 4TB in size.

For efficient access to objects, we have partitioned the sky into 32768 equal-area spatial regions, each of which is the leaf node of a Hierarchical Triangulated Mesh (HTM) Quad-Tree and is an Objectivity Database. Individual plate measurements and catalogues are stored as containers within each database, along with a master index container which is used to provide low-overhead links between object measurements and external references.

We have currently constructed the individual databases for our production system, and have already loaded the measurements from the first Guide-Star Catalogue, which was previously constructed to support the Hubble Space Telescope. Additional measurements are now being loaded into this federated database and we expect to complete catalogue construction and calibration over the next 2-3 years.

We also give an overview of the planned capabilities of the database to allow the exchange of information between this and other external distributed databases such as the SDSS or 2MASS who plan on adopting the same sky partitioning scheme. This will allow for efficient cross-identification of objects from different databases and will provide a powerful tool for future researchers.

55.02

JPL's Near-Earth Asteroid Tracking (NEAT) Program: A Fully Automated, Remotely Controlled, Digital Sky Survey.

D. Rabinowitz, E. Helin, K. Lawrence, S. Pravdo (JPL)

The Near-Earth Asteroid Tracking (NEAT) program is the first fully automated system for controlling a remote telescope, acquiring wide-field digital images, and detecting near- Earth objects (NEOs). Under an agreement between the Jet Propulsion Laboratory (JPL) of the California Institute of Technology and the U. S. Air Force, JPL is provided access to a 1.0 m telescope located at the 3000 m summit of Haleakala crater in Maui, Hawaii. During NEAT operations, a thermo-electrically cooled CCD camera, constructed by JPL using a Lockheed 4K×4K CCD with 15 micron pixels and 4-quadrant readout, is mounted at the f/2.15 Ritchey-Cretian focus, thus providing a 2.6 sq. deg. field. High-speed electronics built by San Diego State University control the CCD and read out the full-resolution image in 20 sec. An on-site JPL computer is programmed to move the telescope through a scripted sequence of positions, to acquire CCD images, and to measure the position and brightness of every moving object. By scripting 20 sec exposures every 40 secs, this system can image up to 1000 sq. deg. thrice nightly to magnitude limit V=19.5, and can detect asteroids with 90% efficiency to V=18. As of April 1998, NEAT has surveyed approx. 26000 sq. deg., detected approx. 23000 asteroid, and discovered 28 new NEOs. The current rate of NEO detections, including incidental redetections, is about 2 per 1000 sq. deg., of which half are larger than 1 km. All images are being archived and made accessible through the SKYMORPH web interface (see presentation by S. Pravdo *et al.*). A proposal is currently under review to run the NEAT program on three Air Force telescope, 18 nights per month. Such a system would cover the whole night sky 3 times per month to V=20, and detect 90% of the NEOs larger than 1 km in 10 to 20 years.

55.03

Spatial Density Reconstruction of the Large Magellanic Cloud galaxy: Halo Profile and the limits on the LMC mass

Sergei Nikolaev, Martin D. Weinberg (U. Massachusetts)

A parametric method of estimating three-dimensional spatial density given source positions and multiband photometry is presented. The luminosity function is determined simultaneously. The parameters are evaluated by a Maximum Likelihood scheme using Markov Chain Monte Carlo. The method has the potential of combining the data from different surveys and of different nature (e.g. kinematics and photometry).

The technique is applied to the Large Magellanic Cloud. We use JHK_s photometry of 3 $6^\circ \times 1^\circ$ fields observed by the 2MASS southern facility. Fields located at the periphery of the LMC allows us to probe the extent of the LMC halo. A range of models, including gaussian, exponential and power law halos is explored. The mass estimates are obtained from dynamical arguments combined with the inferred spatial density profile. The uncertainties of the method are statistical and can be reduced by increasing the sample. The technique is formally free of any bias, except the one introduced by the choice of the model; the bias may be eliminated by the use of non-parametric density estimator.

55.04

Field Brown Dwarfs Discovered by 2MASS and the Definition of a New Spectral Type Cooler Than "M"

J. D. Kirkpatrick, R. M. Cutri, B. Nelson, C. A. Beichman (IPAC, Caltech), I. N. Reid (Caltech), J. Liebert (U. Arizona), C. C. Dahn, D. G. Monet (U.S. Naval Observatory, Flagstaff), M. F. Skrutskie (U. Massachusetts, Amherst)

Before the 2-Micron All-Sky Survey (2MASS) began, only six objects were known with spectral types later than M9.5 V, the end of the M-dwarf sequence: GD 165B, Gl 229B, Kelu-1, and three cool objects discovered by the DEep Near-Infrared Survey (DENIS). In the first 421 sq. deg. of actual 2MASS survey data, we have identified another twenty such objects spectroscopically confirmed using the Low Resolution Imaging Spectrograph (LRIS) at the W. M. Keck Observatory. Specifically, we searched for 2MASS objects having no optical counterparts in the POSS-I survey, an IR detection with $K_s<14.5$, and colors of either $J-K_s>1.30$ (like GD 165B) or $J-K_s<0.4$ (like Gl 229B). At least six of these new "post-M" dwarfs show the 6708-Å lithium doublet *at low resolution*. For objects this cool, the presence of lithium proves that they are substellar. Another four objects appear to have lithium lines at the limit of our detectability (~1 Å equivalent width) which if verified means that at least half of the 2MASS "post-M" objects are bona fide brown dwarfs. Because the TiO and VO bands which dominate the far-optical and near-infrared portions of late-M spectra disappear in these cooler dwarfs, we will define a new spectral class — spanning roughly 2000-1500K — where metallic oxides are replaced by metallic hydrides as the major spectroscopic signatures. These very cool objects will most likely be christened as either spectral class "H," "L," "T," or "Y." The choice of letter will be made in advance of the meeting after a thorough discussion with experts on the MK classification system. All of the 2MASS brown dwarfs discovered so far have $J-K_s>1.30$. We have not yet, despite deliberately searching for them, found any brown dwarfs with colors resembling the methane brown dwarf Gl 229B. A discussion of the lithium signatures and implications for the substellar mass function will be given in a companion paper by Reid *et al.*

55.05

Morphological Galaxy Counts from the Digitized POSS-II

S. C. Odewahn, S. G. Djorgovski, R. Gal (Caltech), R. R. de Carvalho (Observatorio Nacional, Brasil)

We present preliminary results from a three-color survey of selected high-latitude fields of the digitized Second Palomar Observatory Sky Survey (DPOSS).

Innovative automated image classification techniques employing artificial neural network pattern classifiers are used to establish catalogs of stars and galaxies to an approximate magnitude limit of $g_J \leq 21$ mag. A variety of global photometric properties and Fourier image models are extracted from the JFN galaxy images having diameters measured at the 25 mag arcsec^{-2} isophote larger than 30″. A multi-dimensional analysis of these quantities is performed using artificail neural networks to develop a viable galaxy morphology classifier for the DPOSS material. We present a new morphological classifiction approach using Fourier image models to identify barred and ringed spiral systems.

The resultant multi-color photometric catalog is used to compute morphological galaxy number counts in 3 bands (photographic JFN calibrated to Gunn gri). These data will be compared to predictions from non-evolving and evolving galaxy models and serve as a fiducial measure of galaxy number counts at intermediate flux levels. The results are discussed in the context of related studies of the high redshift Universe made with the Keck telescopes and HST.

This work is supported in part by a grant from the Norris Foundation.

WEDNESDAY

55.06

SkyMorph: A 3-Dimensional Sky Archive

S. H. Pravdo, E. H. Helin, D. L. Rabinowitz, K. J. Lawrence (JPL), T. A. McGlynn (GSFC)

SkyMorph is an archive of visible images of the sky and information associated with these images. The archive covers much of the sky but its salient feature is that each area of the sky is re-observed several times at different timescales allowing the possibility of detecting celestial variability either in the positions of objects - asteroids, comets, high-proper motion stars; or in the intensity of objects such as novae, supernovae, or bursters. SkyMorph is accessible through the WorldWideWeb at http://skys.gsfc.nasa.gov/skymorph/obs.html or at http://starlet.jpl.nasa.gov/skymorph/obs.html. As this is written the archive consists of 31 nights of data, or 12000 images, most of them 1.6×1.6 degrees on a side. The images come from the Near-Earth Asteroid Tracking (NEAT) program and are acquired with a 4096×4096 CCD camera mounted on a 1-m telescope on Haleakala Crater, Hawaii. NEAT started observing in December 1995 and continues to observe every month for six nights. The total number of nights of observations is now 174. Prior nights are being added to the archive at a rate of about 1 night/day. The digital information from each field includes the Right Ascension and Declination positions of all detected objects, their intensities, and eventually the time behavior of these quantities. Current display capabilities include the catalog of images on the sky, multiple observations of the same field, RGB overlay of fields that show stationary objects in white and moving objects in color, and the object information. SkyMorph is sponsored by NASA Code SR's Applied Information System Research program.

55.07

New Populations of IR-Selected AGN: Initial Results From 2MASS

B. Nelson, R. M. Cutri, J. D. Kirkpatrick, C. A. Beichman, C. Lonsdale (IPAC), J. Huchra (CfA), M. F. Skrutskie (U. Massachusetts, Amherst)

There is growing evidence that a significant fraction of QSOs in the universe may have remained hidden from optical and UV surveys because of obscuration by dust in and around their nuclei. The Two Micron All-Sky Survey (2MASS) which began northern operations in June 1997, will provide a means to discover many of these obscured QSOs. We have undertaken a pilot search to identify obscured Seyfert galaxies and quasars based on infrared colors in the growing 2MASS database. Our initial results from the first six months of 2MASS operations are very encouraging. In 667 square degrees of survey data (a small, fully processed subset of the >10,000 sq. deg. of data obtained so far) 165 previously unidentified objects redder than J-K_s > 2.0 have been found. Spectroscopic follow-up of 28 candidates has yielded 19 new AGNs, for a success rate of 68%. About 2/3 of these are Seyfert 1s and QSOs and the rest are Seyfert 2 galaxies. The highest redshift 2MASS-discovered QSO has z=1.8 and $L_{bol} \approx 10^{12} L_{\odot}$. The derived density on the sky of 0.17 per square degree would deliver 6900 new discoveries by the end of the survey. Relaxing the color criterion slightly to J-K_s>1.90 doubles the number of candidates, indicating that there may be >10,000 of these objects waiting to be discovered.

55.08

The Amateur Sky Survey (TASS): Two Years and Counting

M. W. Richmond (RIT), T. Droege, C. Albertson, G. Gombert, M. Gutzwiller, H. Johnson, R. Wickersham (TASS), A. Henden (USRA/USNO), N. Beser, M. Pittinger, B. Kluga (JHU/APL)

The Amateur Sky Survey (TASS), a small group of amateurs and professionals working together informally, has been scanning the celestial equator with CCD cameras for almost two years. We present a status report on the results so far, which include V-band and I-band measurements for many hundreds of thousands of stars. As we expected, it is a difficult job to calibrate properly scans from different nights and different sites.

55.09

The New APS Catalog of the POSS I

J. R. Kriessler, R. M. Humphreys, J. E. Cabanela, R. F. Rees, H. Ngo, J. Srivastava (U. Minnesota)

The Automated Plate Scanner (APS) project includes three separate on-line databases or catalogs based on our digitized scans of the POSS I – the APS Catalog of the POSS I is an object catalog of matched images that contains coordinates, magnitudes, colors, and other image parameters; the high-resolution image database of all detected images, and the new Luyten proper motion database now in progress. A new version of the POSS I objects catalog is now coming on-line with improved classification for faint objects plus other new features. We discuss the development of new Web access tools for the manipulation and visualization of the Catalog and image database including an improved batch query mode and the new federated database for cross-database access. We also discuss our progress toward automated morphological classification for all galaxies in the database with diameters greater than about 15 arcsecs and new software to identify blended images in the object catalog.

55.10

GSC-II: An Overview of Current Catalogue Construction

B. McLean, B. Lasker (STScI), M. Lattanzi (OATo)

The Catalogs and Surveys Branch of the Space Telescope Science Institute, in collaboration with the Osservatorio Astronomico di Torino, the GEMINI project and ESA, is constructing a second generation Guide Star Catalogue (GSC-II) of astronomical objects to support the operations of current and future ground and space based telescopes.

The second generation sky survey plates (POSS-II and SES) are being digitized at STScI, which when combined with the first epoch plates will allow us to produce a catalogue containing positions, proper motions, magnitudes and colurs to at least 18th magnitude for operational purposes.

In addition to constructing such a catalogue, STScI is also compressing the second generation plate images using the same technique used for the DSS-I and is making the scan data available to the community in advance of a more general data distribution on CD/DVD.

In this presentation we report on the status of the plate digitization, compression and plate processing. A separate contribution will describe the unique database aspects of this project.

55.11

2MASS Galaxy Catalog: First Results

T. Chester, T. Jarrett (IPAC, Caltech/JPL), S. Schneider, M. Skrutskie (UMASS Astronomy Program), J. Huchra (Harvard-Smithsonian CfA)

The 2MASS data processing began in mid-April 1998. We will present an overview of the extended sources produced in the first month of processing. The data set is expected to cover 2-4observed J-K color, a proxy for redshift (see Jarrett, T. et al, this meeting), log N / log S, J-H vs. H-K color-color plots, and the variation in numbers of galaxies with sky coordinates. The results will be posted online as they become available.

55.12

Color Space Simulation in SDSS System

X. Fan (Princeton University Observatory)

We present a Monte-Carlo simulation of the color-magnitude distribution of four kinds of point sources in the color system of the Sloan Digital Sky Survey (SDSS). We simulate (1) galactic stars, based on stellar population synthesis models and a model for the Galaxy; (2) quasars, based on the observed evolution of the quasar luminosity function and the statistical properties of quasar emission lines and absorption systems; (3) white dwarfs, based on the observed white dwarf luminosity and mass distribution and

model white dwarf atmospheres; and (4) compact emission line galaxies, based on their luminosity function and emission line properties. This simulation can be used in the SDSS survey for establishing quasar selection criteria, calculating the quasar selection function and studying star counts and Galaxy models. We also compare our simulations with the observed colors of stars and quasars in the SDSS color system.

55.13

A Digital Emission-Line Survey of the Small Magellanic Cloud

Y. Rathore, P. F. Winkler (Middlebury College), R. C. Smith (U. Michigan & CTIO)

We present results on the SMC from the first full season of the Michigan/CTIO Magellanic Cloud Emission-Line Survey, being carried out from the 0.6m Curtis Schmidt telescope at CTIO. The 1°.1 square field of the 2K STIS CCD on the Schmidt makes digital surveys of both Clouds a practicable goal. Images are being obtained in Hα, [S II] $\lambda\lambda$6717,6731, and [O III] λ5007, plus red and green continuum bands for star subtraction. During the 1996-97 season, a 3°.5 × 4° region encompassing most of the SMC was covered by observing 34 overlapping fields in all five wavelength bands. These data are being assembled into large mosaic images which reveal the rich variety of nebulosity in the SMC in unprecedented detail. These data will eventually provide definitive samples of the active ISM on scales including superbubbles, wind-blown bubbles, supernova remnants, H II regions, and planetary nebulae.

Combining the images into seamless mosaics covering such a wide field, especially at high declination, presents a challenge. We will describe techniques we have developed or adapted to maintain an astrometric accuracy of 1″ over the entire field, avoid significant degradation of resolution, and achieve near-uniform sky levels across the field.

This work has been supported in part by the NSF through grants AST-9618465 and AST-9530747, and by the W.M. Keck Foundation through the Keck Northeast Astronomy Consortium.

55.14

NoSOCS: The Northern Sky Optical Cluster Survey

R. Gal, S. C. Odewahn, S. G. Djorgovski, R. Brunner (Palomar Observatory, Caltech), R. R. DeCarvalho (CNPq/ON, Brazil)

We report on an effort to create an unbiased catalog of clusters of galaxies from the galaxy catalogs derived from the digitized POSS-II (DPOSS). We use a simple color selection of candidate cluster galaxies, coupled with the adaptive kernel method to generate galaxy surface density maps. A bootstrap technique is then used to generate the statistical significance map associated with a given surface density map. This map is then used to detect overdensities of galaxies on the sky which indicate candidate galaxy clusters. In our test fields, we recover all of the known Abell clusters, and find a number of new ones. We have also begun a program of follow-up spectroscopy and five-color imaging of our cluster candidates, to check if our candidates are truly clusters and measure their redshifts. Eventually, we plan to generate an objectively defined, statistical catalog of groups and clusters, with well defined selection criteria, over the entire high-latitude northern sky.

55.15

2MASS Galaxy Colors: Hercules Cluster

T. H. Jarrett (IPAC/Caltech/JPL), T. Chester (IPAC/Caltech/JPL), J. Huchra (CfA), S. Schneider (Univ. of Massachusetts)

The 2 Micron All Sky Survey (2MASS), now underway, will observe somewhere between 1 and 2 million galaxies with high completeness and reliability down to J = 15 and Ks = 13.5 mag. About 0.01% of this catalog will be comprised of galaxies from the Hercules cluster, a large fraction of which was recently acquired by the 2MASS project. As part of a 2MASS engineering and early check-out run the Hercules cluster was observed multiple times to assess photometric repeatibility and completeness & reliability. A summary of the repeatibility results and sensitivity limits for 2MASS galaxy photometry is given.

We present the JHKs colors and redshifts for galaxies located toward the Hercules cluster. Our main conclusions for Hercules are that (1) galaxies have a well-defined, restricted location of J-H & H-Ks colors, (2) the galaxy color-color plot is quite different from the point source color- color plot, and is consistent with the expected redshift distribution of 2MASS galaxies, (3) the change in galaxy color versus redshift (the K-correction) can be used to obtain statistical redshifts of 2MASS galaxies from the 2MASS galaxy color-color diagram, and (4) except for z greater than 0.3, the similar K-correction for elliptical and spiral galaxies renders limited statistical separation using the 2MASS color-color diagram.

55.16

The Halo Population of Very-Low-Mass, Metal-Poor Stars

J. E. Gizis (U. Mass at Amherst), I. N. Reid (Caltech)

We present a study of the very-low-mass ($0.1 < M < 0.3$ solar masses) metal-poor stellar population of the Galactic halo based upon a new sample of proper-motion stars discovered using the Palomar Sky Surveys. We find that the metallicity distribution of these stars is consistent with that of halo G stars. The kinematics of the VLM stars is also consistent with that determined locally for higher mass metal-poor stars. Transformation of our observed luminosity functions into the mass functions is complicated by the uncertainties in stellar models. Our best estimate is that the stellar IMF is at most weakly dependent on metallicity. In addition, we present preliminary results of a Hubble Space Telescope search for nearby binary M subdwarfs. Constraints on the binary fraction of metal-poor stars and the prospects for determining the first empirical masses for these stars are discussed.

55.17

2MASS Brown Dwarfs and the Substellar Mass Function

I. N. Reid (Palomar Obs., Caltech), D. Kirkpatrick, C. A. Beichmann (IPAC, Caltech), J. Liebert, A. Burrows (U. Arizona), M. Skrutskie (U. Massachusetts)

Analysis of a complete sample of brown dwarf candidates with (J-K) > 1.30 and K < 14.5, drawn from 2MASS observations of 420 square degrees, or 1 percent of the sky, confirms 17 sources as extremely cool, meta-M dwarfs. Five of the 17 have detectable (>2 Å equivalent width) lithium absorption in Keck LRIS spectra, implying masses of less than 0.07 solar masses. While none of these objects has a measured parallax, we have compared the observed effective temperature and lithium-depletion distributions against predictions based on Monte Carlo simulations. The latter use the recent Burrows *et al.* theoretical calculations to model brown dwarf characteristics (L(M, t), Temp(M, t)), and, based on a variety of assumed mass functions and star-formation histories, predict the (K, (J-K)) colour-magnitude diagram described by local brown dwarfs. These simulations can be ''observed'' with 2MASS-equivalent filter. This paper presents the initial results from comparisons between the models and reality.

55.18

The APS-Luyten Proper Motion Project

R. F. Rees, Jr., R. M. Humphreys, C. S. Cornuelle (U. Minnesota)

As part of the Minnesota Automated Plate Scanner project, we are repeating the proper motion survey for which the machine was originally built. We have scanned the Palomar Schmidt red plates taken by Willem Luyten in the 1960's with glass copies of the POSS I red plates. Epoch difference varies from field to field but is typically in the range of 11-15 years. With the upgrade to the APS and improvements in computing since Luyten's original survey, we expect to measure the relative displacements of objects between the first and second epoch plates to the APS limiting accuracy, about 1 μm

(0.″07). This corresponds to a relative proper motion precision of 0÷''006 year^{-1} for a 12-year baseline. Objects classified as galaxies in the APS catalog of the POSS I will be measured along with the stars and used to set the absolute proper motion zero-point. The survey will cover the 664 fields with $|b|>20°$, and we estimate the proper motion catalog to contain several tens of millions of stars brighter than E magnitude ~20, **making it the largest such catalog in existence.** The APS-Luyten Proper Motion Database will join the APS Object and Image databases online as a single federated database and will be available to the astronomical community. The database will be useful for placing both kinematic and structural constraints on Galactic models, as well as the search for Pop II white dwarfs, lower main sequence stars, brown dwarfs, common motion pairs, moving groups, and other interesting objects. This paper describes our recent progress and future plans.

55.19

Over a Quarter Million Galaxies at the North Galactic Pole

J. Cabanela, R. M. Humphreys (U. Minnesota)

We have constructed a two-color catalog of galaxies found on the APS digitized scans of the POSS-I within 30 degrees of the North Galactic Pole (NGP). This is a complete sample of over 2.5×10^5 galaxies with major-axis diameters greater than 10 arcseconds. Evidence is presented to show that the major-axis diameters retrieved from the Minnesota Automated Plate Scanner (APS) are roughly isophotal down to an isophote of 23 magnitudes per square arcsecond. This machine built catalog is the largest catalog of galaxies with roughly isophotal diameters and provides an excellent sample for investigating the diameter function of galaxies. This survey in concert with other surveys in other bandpasses will provide critical information about the large-scale structure visible at the NGP.

55.20

Correlating FIRST and DPOSS: A Search for Radio-loud Quasars at z~4

D. Stern, H. Spinrad (UC Berkeley), W. van Breugel (IGPP), S. Djorgovski, S. Odewahn, R. Gal (Caltech), R. de Carvalho (ON/CNPq, Brasil)

High–redshift quasars provide some of the earliest glimpses we have of the Universe, constrain models of structure formation, and are valuable probes of the intervening intergalactic medium. We are pursuing a program to find high–redshift, radio–loud quasars. The search technique relies upon two new large–area surveys of unprecedented depth and accuracy: the FIRST survey (Faint Images of the Radio Sky at Twenty Centimeters) — a VLA effort mapping the Northern sky with 1.0^s positional uncertainty to a limiting flux of $S_{1.4\,\mathrm{GHz}} = 1$ mJy, and the DPOSS (digitized Second Palomar Observatory Sky Survey) — a photographic montage of the northern sky in three pass bands: blue (g;$\lambda_{\mathrm{eff}} \sim 4800$ Å), red (r;$\lambda_{\mathrm{eff}} \sim 6500$ Å), and infrared (i;$\lambda_{\mathrm{eff}} \sim 8500$ Å). Typical limiting magnitudes are 22.5^m, 20.8^m and 19.5^m, respectively; *i.e.*, ~ 1 – 1.5 magnitudes deeper than the POSS–I and with an additional redder plate. Correlating these large radio and optical catalogs, we find optical identifications for the radio sources and select red objects which are classified as stars by DPOSS for spectroscopic observation. We have found the two most distant quasars selected from the FIRST survey to date: FIRST 1410+3409 ($z = 4.36$) and FIRST 0100 − 0128 ($z = 3.85$).

Session 56: Frontiers of Ultraviolet Astrophysics Display Session, 10:00am-6:30pm Atlas Ballroom

56.01

The Halo Ultraviolet Explorer

Jayant Murthy (JHU)

We have proposed the Halo Ultraviolet Explorer (HUE) as a University-class Explorer. This consists of a spectrograph (850-1200 A) optimized to detect diffuse O VI (1032/1038 A) emission from the hot Galactic halo. With sensitivities an order of magnitude better than any previous experiment, we will, for the first time, unambiguously detect such lines revealing densities, temperatures and pressures in the halo. The first mission designed specifically to probe the diffuse UV sky, HUE will map supernova remnants and other active regions in the far-UV, where many emission lines critical to the understanding of the violent ISM lie. We will observe dust-scattered starlight from dust in disparate regions, from cold molecular clouds to reflection nebulae near hot stars, testing models of dust evolution and composition in different environments.

If selected, HUE will fly in mid-2001 for a 3 month mission using a Spartan Lite bus. Building upon decades of experience at the Johns Hopkins University, we have put together a mission to perform ground-breaking astrophysical research at remarkably low cost and risk.

56.02

Simulations of FUSE Spectra of A-type and Cooler Stars: D/H and Warm Plasma Emission

D. O'Neal, J. L. Linsky (JILA/U. Colorado)

The Far Ultraviolet Spectroscopic Explorer (FUSE) will observe many stars in the 905–1187 Å spectral region with a resolving power of 24,000–30,000. FUSE will explore this critically important spectral region, which is mostly inaccessible to HST (and previously to IUE), observing sources much fainter than Copernicus and with much better spectral resolution than HUT or ORFEUS.

We present simulations of stellar spectra that will be observed with FUSE. The FUSE bandpass includes the Ly β (1025 Å) and Ly γ (972 Å) lines. Extrapolating from GHRS Ly α spectra, we simulate FUSE spectra of the Ly β and Ly γ lines of Capella and some other late-type stars. These simulations will address the accuracy with which the interstellar D/H ratio can be measured using these lines.

In addition, one of our FUSE observing programs will measure for the first time the amount of warm (60,000–300,000 K) plasma present in the outer atmospheres of A and early-F stars, using the C III 977 Å and O VI 1032 Å lines. This program will explore whether the outer atmospheric layers of these stars are heated to these temperatures and whether the heating process is magnetic or acoustic. Our simulations indicate that FUSE will be sensitive enough to measure very low luminosities in these lines.

This work is supported by NASA grants to the University of Colorado.

56.03

ORFEUS Observations of the Contact Binary 44i Boo

N. S. Brickhouse, A. K. Dupree (Smithsonian Astrophysical Observatory)

We report ORFEUS observations of the contact binary 44i Boo (HD 133640) at two orbital phases (0.91 and 0.40). The contact binaries provide the exception to the rule of increasing magnetic activity with rotation rate among cool stars, as the radiation reaches a constant maximum level for the fastest rotators. The ratio of emission lines C III λ977; λ1176 indicates relatively high electron density, $N_e = 2 \times 10^{10}$ cm^{-3} at $T_e \sim 6 \times 10^4$ K, with a pressure five orders of magnitude less than the coronal pressure at $T_e = 6 \times 10^6$ K determined from EUVE (Brickhouse & Dupree 1998, ApJ, 502, in press). The shape of the emission measure distribution for the system from $T_e \sim 3 \times 10^4$ to the limit temperature $T_e \sim 2 \times 10^7$ K is determined from IUE, ORFEUS, EUVE, and ASCA, with ORFEUS providing the critical O VI λ1032 ($T_e \sim 3 \times 10^5$ K), linking the upper transition region to the coolest observed EUV Fe ion (Fe IX at $T_e \sim 6 \times 10^5$ K). The minimum occurs near 6×10^5 K, reminiscent of that of Capella.

Emission lines shifted by the relative orbital velocity (~200 km/s) between the two stars would be separable at ORFEUS resolution at both phases; however, the line profiles of Si III λ1206, C III λ977, and O VI λ1032, sampling a decade of temperatures (from 3×10^4 to 3×10^5 K), are not consistent with such a simple model. Moreover, these three line profiles show significant differences from each other. Since IUE light curves of lower transition region lines (C II, C IV; see Vilhu, Neff, & Rahunen 1989, A&A, 208, 201) are consistent with the partial eclipses observed in the photosphere, these new line profile measurements present an intriguing clue to the puzzle of coronal heating and confinement.

56.04

Warm Winds of Hybrid Stars

A. K. Dupree, N. S. Brickhouse (SAO)

ORFEUS spectra of two hybrid stars α Aqr (G2 Ib, HD 209750) and α TrA (K2 II, HD 150798), and β Dra (G2 Ib-IIa, HD 159181) cover the far ultraviolet region $\lambda\lambda$912–1218 with a moderate resolution of ~3000. Blue-shifted O VI (λ1032) and C III (λ977) emission relative to Si III (λ1206) is detected in the two hybrid stars, and the markedly narrow resonance line profiles of C III and Si III in the two hybrid objects as compared to the coronal star β Dra also suggest wind absorption. The observed Doppler shifts could be caused by a warm wind of at least 3×10^5K in the hybrid stars with outflows ~100–200 kms^{-1}. An asymmetric profile of C III in β Dra might also result from wind absorption, although the acceleration would have to begin at higher temperatures (T~7000 K) in this coronal star as compared to the hybrids. Electron densities determined from C III multiplets in β Dra and α TrA indicate values between 8.3–8.6 dex (cm^{-3}), giving a pressure of $\sim 2\times10^{13}$cm^{-3}K at T~7×10^4 K. Wind absorption and interstellar extinction must be considered when applying emission line diagnostics in this wavelength region. These observations make the connection between hot and cool winds across the color-magnitude diagram, by demonstrating that intermediate warm winds exist among luminous stars.

56.05

An IUE Far Ultraviolet Spectral Atlas

J. S. Nichols (Caltech/IPAC), J. L. Linsky (JILA/U. Colorado)

The NEWSIPS reprocessing of IUE data accurately follows and extracts the echelle spectral orders and properly subtracts the interorder background even at the shortest wavelengths. NEWSIPS therefore permits the extraction of spectra to wavelengths as short as 1150 A. We present representative well-exposed IUE spectra covering the 1150-1220 A region with a resolution of 0.1 A which will be included in an IUE FUV Spectral Atlas. These spectra consist primarily of O, B, and WR stars, but also include a few of the brighter late-type stars as well as other types of objects. Stellar features include the CIII 1175 A, SiIII 1206 A, SiII 1190, 1193 A lines and an unidentified feature near 1154 A. Many of the WR stars also show a broad emission feature at 1173-1185 A which may be due to CIII or NIII. The CIII 1175 A line in OB giants and supergiants typically shows a P-Cygni shape. Superimposed on the stellar spectra are many strong interstellar absorption lines of NI, SiII, and other species.

The IUE FUV Spectral Atlas provides a useful bridge between the HST GHRS/STIS spectra and the FUV spectra to be obtained by FUSE in the 900-1180 A spectral region. Since IUE observed several hundred targets with well-exposed SWP-HI spectra in the range 1150-1200 A, the Atlas can be an important tool for selecting targets to be observed by FUSE.

Session 57: Interstellar Scattering and Scintillation as Tools in Radio Astronomy
Display Session, 10:00am-6:30pm
Atlas Ballroom

57.01

Characterization of Refractive Scintillation Events detected in Pulsars Timing at the Nancay Radiotelescope

I. Cognard, J.-F. Lestrade (LPCE/CNRS & Obs. de Paris/Meudon)

We will present more than 9 years of timing observations at Nancay on the pulsars PSR B1821-24, PSR B1937+21 including measurements of both TOAs (Time Of Arrivals) and flux densities. We have identified several refractives scintillation events in the data collected on those two pulsars. We will present the criteria chosen to identify those events and discuss the physical parameters of the corresponding discrete clouds resulting from our modelisation.

57.02

High-Frequency Scattering of the Crab Pulsar Giant Radio Pulses

T. H. Hankins (New Mexico Tech), D. A. Moffett (University of Tasmania)

We have recorded "Giant" radio pulses from the Crab Nebula pulsar at the VLA for several years at a variety of frequencies between 0.33 and 8.4 GHz, and occasionally at two frequencies simultaneously. Our time resolution (10 ns) allows us to study the pulses with unprecedented detail. At low frequencies the pulses are broadened by interstellar scattering; we find that the scattering parameters are time variable. At the highest frequencies we find pulse broadening times that scale with frequency more slowly than λ^4, and we find single pulse periods in which pulse components show different scattering broadening. The high-frequency broadening may be intrinsic to the pulsar, either through the emission mechanism or by scattering in the pulsar magnetosphere.

57.03

An Intra-Day Variability (IDV) Survey of Southern Flat-spectrum Radio Sources

L. Kedziora-Chudczer (ATNF, CSIRO & RCTA, Sydney U.), D. L. Jauncey, M. Wieringa, J. E. Reynolds, A. K. Tzioumis (ATNF, CSIRO), G.D. Nicolson (Hartebeesthoek Radio Astron. Obs.), M. A. Walker (RCTA, Sydney U.)

We have carried out a survey of 126 flat-spectrum compact radio sources at 2.4, 4.8 and 8.6 GHz with the Compact Array of the Australia Telescope National Facility. Flux densities were measured with an accuracy of 0.5/that showed variations of 2/up to 2 days were noted. We find that the fraction of sources that show intra-day variations is roughly constant at 6/4.8 and 8.6 GHz. We show the sky distribution of the IDV sources and discuss the Survey results in terms of interstellar scattering as the cause of the variations.

Session 58: Future of Antarctic Astrophysics
Display Session, 10:00am-6:30pm
Atlas Ballroom

58.01

Education and Outreach from the End of the Earth

R. H. Landsberg (CARA - The University of Chicago)

For the past eight years the Center for Astrophysical Research in Antarctica (CARA) has operated an observatory at the South Pole; and for the past nine years CARA has organized educational and outreach efforts that capitalize on the appeal and uniqueness of Antarctica. CARAs programs have reached all levels of the education continuum with an emphasis on minority precollege students. The kinds of educational activities that have been developed are as varied as the audiences. CARA outreach efforts have included hands-on laboratories, nationally televised events (Live from Antarctica), science camps, web based activities, industrial design courses (Extreme Cold Weather Design at the Art Institute of Pittsburgh), public lectures, and educational trips to the South Pole. We partially attribute the success of such a wide variety of programs to the subject matter. In addition to providing a natural laboratory, the continent of snow and ice is a powerful tool for education and outreach efforts. Antarctica, like dinosaurs, is a topic that perpetually captures the publics imagination. This inherent fascination facilitates outreach efforts, because it helps to surmount that first and most difficult step of gaining attention. Antarcticas lure provides a hook to engage students, researchers in different fields, policy makers and the general public. The continent is a rich source of topics to study as well. Antarcticas geography, climate, unique view of the sky, position on the globe, history, and role in the global environment are compelling topics in the classroom or for informal education. CARA is an NSF Science Technology Center and is headquartered at the University of Chicago.

58.02

The Submillimeter Polarimeter for Antarctic Remote Observations

G. Novak, J. L. Dotson, T. Renbarger, and D. Chuss (Northwestern University)

The Submillimeter Polarimeter for Antarctic Remote Observations (SPARO), currently under development at Northwestern University, will be used with the Viper South Pole telescope during Austral Winter 1999 to map interstellar magnetic fields in the extended Galactic Center region. The goal of these observations is to discover the large-scale configuration of the magnetic field in our Galaxy's nucleus. The cryostat for this He-3 cooled bolometer array polarimeter has been optimized for South Pole winter-over use. The operating wavelength is 450 microns. Besides the Galactic Center, targets for SPARO observations include star-forming molecular clouds in the Milky Way, and interstellar cirrus.

58.03

The Viper Telescope : An Instrument to Measure Primary and Secondary CMB Anisotropy at Small Scales

G. Griffin, J. Peterson, K. Romer, D. Alvarez, C. Cantalupo, D. Morgan, M. Newcomb, M. Vincent (CMU Physics Dept.), K. Miller (U. Colorado), G. Novak (Northwestern U.), M. Dragovan (U. Chicago), B. Crone (LANL)

Viper is a 2-meter off-axis telescope designed to measure small-scale anisotropy in the Cosmic Microwave Background Radiation. It is currently deployed at the South Pole, operating with a 40 GHz HEMT receiver. We are attempting to measure primary anisotropy in addition to secondary anistropy from the Sunyaev-Zeldovich (S-Z) effect. Preliminary data will be presented, along with a description of plans for future cosmological and non-cosmological observations.

58.04

Three-Point Correlations in the Microwave Sky at 90GHz

J. Jewell, M. Dragovan (Univ. of Chicago, IL.)

We compute the three-point correlations in the microwave sky at 90GHz using the Python III data set. The statistical significance of the results are established with Monte Carlo simulations of the experiment within a chosen Gaussian hypothesis. We also explore an alternative Bayesian approach to the test for non-Gaussianity using models characterized by non-vanishing three-point correlations.

58.05

AST/RO CO (4-3) Observations of the Central Kiloparsec of the Milky Way

T. M. Bania, A. D. Bolatto, M. Huang, J. G. Ingalls, J. M. Jackson (Boston U.), G. W. Wright (Lucent Tech.), A. P. Lane, M. Rumitz, R. W. Wilson, A. A. Stark, X. Zhang (SAO)

We have imaged the CO 4-3 line, the dominant coolant of the dense molecular interstellar medium, from the Galactic Center region, between l=-3 to 4 degrees and b= -1 to 1 degrees. We detect bright CO 4-3 emission from the well-known Galactic Center clouds Sgr A, Sgr B, Sgr C, and Sgr D. We compare the CO 4-3 intensities with CO 1-0, C18O 1-0, HCN 1-0, and HCO+1-0 from the literature to infer excitation conditions. The CO 4-3 traces fairly warm, dense gas with opacities near unity. We also detect CO 4-3 absorption at V=0 km/s along the line of sight toward the Galactic Center.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

58.06

AST/RO Observations of Atomic Carbon in the Galactic Center

R. Ojha, A. A. Stark, A. P. Lane, M. Rumitz, R. W. Wilson (Harvard Smithsonian CfA), R. A. Chamberlin (CSO), G. Wright (Lucent Tech.), T. M. Bania, A. D. Bolatto, M. Huang, J. G. Ingalls, J. M. Jackson (Boston U.)

A coarsely-sampled map of the region $|l|<2$, $|b|<0.1$ has been made in the 492 GHz $^3P_1 - {}^3P_0$ transition of [C I] with the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO). The distribution of [C I] emission is similar on the large scale to that of CO. Systematic differences between [C I] and CO emissivities in Galactic Center clouds are described as a function of cloud properties and environment. On average, the C/^{12}CO ratio is lower in the Galactic Center region than in the outer galactic disk. This difference can be attributed in part to optical depth effects, as shown by the C/^{13}CO ratio, and in part to the existence in the Galactic Center region of molecular and dense atomic gas not bound into clouds.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

58.07

AST/RO Studies of Carbon Gas in High-Latitude Clouds

J. G. Ingalls, T. M. Bania, J. M. Jackson (Boston U.), R. A. Chamberlin (Caltech Submillimeter Obs.), A. P. Lane, M. Rumitz, A. A. Stark (SAO)

The two major tracers of neutral carbon gas, CI and CO, have been observed in 11 southern hemisphere high Galactic latitude ($|b|\gtrsim 10°$) molecular clouds (HLCs) using the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO). Observations of the lowest-lying ($^3P_1 \rightarrow {}^3P_0$) transition of neutral carbon [CI], at 492 GHz, as well as the (J= 2–1) and (J=4–3) rotational transitions of CO, at 230 and 461 GHz, respectively, are presented. HLCs are nearby ($d\sim 100$ pc) translucent clouds ($A_v\sim 1$–5) associated with infrared cirrus. Since the clouds are translucent, destruction of H_2 and CO by the ambient far-ultraviolet (FUV) radiation field dominates their structure. As such they are the simplest regions in which to study molecule formation in the interstellar medium (ISM) in the presence of FUV radiation. The HLCs are probably representative of much of the molecular ISM: $\sim$ 50% of the molecular gas in the Galaxy is translucent. Due to the extremely low submillimeter atmospheric opacity above the Antarctic plateau, AST/RO enables observation of the weak CI and CO lines in translucent clouds with unprecedented sensitivity. Estimates are made of the abundances of CI and CO in the observed clouds. A complete census of carbon gas is possible for a subset of the clouds, which have also been observed in ionized carbon (C^+) emission with the Infrared Space Observatory (ISO). The two transitions of CO are used to constrain physical conditions, and the abundances of C^+, CI, and CO are compared with chemical models.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

58.08

AST/RO Observations of Photodissociations Regions in a Metal-Poor Environment

A. D. Bolatto, J. M. Jackson, T. M. Bania, M. Huang, J. G. Ingalls (Boston U.), R. A. Chamberlin (Caltech Submillimeter Obs.), G. W. Wright (Lucent Tech.), S. P. Balm (UCLA), A. P. Lane, M. Rumitz, R. W. Wilson, A. A. Stark (SAO)

We report observations of the $^3P_1 \rightarrow {}^3P_0$ fine structure transition of neutral carbon ([C I], λ = 609 μm) and the J = 4 $\rightarrow$ 3 rotational transition of CO (λ=652 μm) on the Large Magellanic Cloud.

These measurements were performed using the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO) during the 1995, 1996 and 1997 seasons. Neutral carbon originates in the warm interface regions of molecular clouds known as Photodissociation Regions (PDRs), where CO is split into its atomic components by UV radiation. [C I] emission is thus thought to trace this transition occurring at a visual extinction of a few ($A_v \sim 1-3$). Middle rotational transitions of CO trace relatively dense ($n_H \approx 10^5$ cm^{-3}) and warm ($T > 20$ K) molecular gas. PDR regions are enlarged in low metallicity environments, where the UV penetration is enhanced by the lower dust-to-gas ratios.

We present a semianalytical model for the dependence of the [C II]/CO and [C I]/CO intensity ratios with metallicity and compare its predictions with the available observations of PDRs in metal-poor environments. The study of PDRs in the low metallicity ISM will allow us to better understand the observational diagnostics for the first cosmic epochs of star formation.

This research was supported in part by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

58.09

AST/RO C I and CO 4-3 Observations of the NGC 6334 Star Forming Region

J. M. Jackson, T. M. Bania, A. D. Bolatto, M. Huang, J. G. Ingalls (Boston U.), R. A. Chamberlin (Caltech Submillimeter Obs.), G. W. Wright (Lucent Tech.), A. P. Lane, M. Rumitz, R. W. Wilson, A. A. Stark (SAO)

We have imaged the [C I] $^3P_1 \rightarrow {}^3P_0$ and CO ($4 \rightarrow 3$) lines toward the massive star forming region NGC 6334. The [C I] emission traces the photodissociated skin of molecular clouds, while the CO ($4 \rightarrow 3$) emission traces warm, dense star forming cores. Because NGC 6334 has 7 sites of OB star formation, we can separate the effects of the individual stars and their varying UV fields on the surrounding medium. We compare the [C I] and CO data with images of FIR fine-structure lines, predominantly from photodissociation regions, and lower J lines of CO, primarily from cooler, less dense molecular gas. We examine the predictions of standard PDR models and compare them with the data.

58.10

AST/RO Observations of [C I] in Galactic H II Regions

M. Huang, T.M. Bania, A. Bolatto, R.A. Chamberlin, J.G. Ingalls, J. Jackson (Boston U.), A.A. Stark, A.P. Lane, M. Rumitz, R.W. Wilson (SAO), G. Wright (Lucent Tech.)

We present the results of a study of atomic carbon ($^3P_1 \rightarrow {}^3P_0$) emission from Southern Hemisphere H II regions using the Antarctic Submillimeter Telescope and Remote Observatory (AST/RO).

One part of our H II region sample consists of 49 compact, relatively isolated members of the Wilson *et al.* (1970) hydrogen radio recombination line (RRL) emission catalogue. Most [C I] spectra of the sample show multiple emission components, and every H II region has associated [C I] emission near the RRL velocity. The mean ⟨FWHM⟩ linewidth of these [C I] components is 6.8 ± 3.0km s^{-1}; this cannot be explained by thermal broadening and indicates that turbulent broadening is important. RRL-associated [C I] emission components are brighter than those not associated with H II regions, which suggests that the [C I] intensities are dominated by local heating.

The second part of our sample consists of 11 H II regions from the Caswell and Haynes (1987) radio recombination line catalogue. We have observed fine-structure C^+ (157 μm) emission using the Long Wavelength Spectrometer (LWS) on board the ISO satellite. We have also observed both CO J=4-3 and [C I] emission using AST/RO, and $H_{91\alpha}$, $H_{92\alpha}$ RRLs using the 140-foot radiotelescope at NRAO Greenbank. We discuss the physical properties of the H II regions based on the different tracers of ionized, neutral, and molecular gas in the sample.

This research was supported by the National Science Foundation under a cooperative agreement with the Center for Astrophysical Research in Antarctica (CARA), grant number NSF OPP 89-20223. CARA is a National Science Foundation Science and Technology Center.

58.11

IMAPS Observations of NI in the Local ISM

C. Johns Krull, B. Y. Welsh, J. Vallerga (Eureka Scientific), R. Lallement (Service d'Aeronomie, CNRS, France)

We present high resolution absorption spectra of the interstellar NI triplet at 1134 Angstroms for 3 nearby stars in the local interstellar medium (Alpha Pav, Alpha Leo and Alpha Gru). These spectra were taken with the IMAPS instrument on the Astro-Spas II mission in December 1996, and the absorption profiles are compared with high resolution interstellar CaII K-line data to investigate the complex velocity structure of neutral gas within 60pc of the Sun

Session 59: NSF Town Meeting
Extra, Oral Session, 1:00-2:00pm
Friars

59.01

NSF, Introduction

Hugh M. Van Horn (NSF)

This session will provide an update of the status of the FY 1998 budget and summarize some other developments at NSF of interest to U.S. astronomers. Hugh Van Horn also wants to engage in a general discussion with the audience. It is vitally important that NSF understand the issues confronting our colleagues in astronomy across the nation.

Session 60: Committee on the Status of Women in Astronomy
Committee, Oral Session, 1:00-2:00pm
DeAnza/Mesa

60.01

The Mathematics of Truth and Beauty: Emmy Noether, Symmetry and the Seduction of a Science Writer

K. C. Cole (LA Times)

The universe is a complicated place, and journalists, astronomers, philosophers and poets are all preoccupied with trying to make sense of it. Curiously, many people outside the sciences do not make use of one of the most powerful tools available: the language of mathematics. Mathematics brings surprising clarity to an astonishing range of issues, from cosmic questions (the fate of the universe), to social controversy (race and IQ scores) to matters of public policy (voting and fairness). These tools are easily accessible to lay people–including even reporters, and females, despite persistent assumptions to the contrary. This writer, in particular became entranced by the connection between fundamental laws of nature and symmetry established by the mathematician Emmy Noether–and its implications "outside the walls" of science.

Session 61: IRAF Users' Group Meeting
Extra, Oral Session, 1:00-2:00pm
Forum

61.01

IRAF, Introduction

George Jacoby (U. Arizona)

Members of the IRAF User's Committee and the IRAF software development groups from NOAO and elsewhere will hold an informal discussion for users of the IRAF data analysis system. A short presentation will outline recent upgrades, present status, and long-term plans for major changes in the IRAF system. Users are invited to comment on these plans and suggest priorities for future work, as well as to meet with IRAF programmers for one-on-one discussions.

Planning is underway to migrate the IRAF software to a more modern, state-of-the-art, software architecture. With limited resources and the ongoing support requirements of the current system, this process will take some years, but the work will be done in stages and parts of the new system will be released as they become available. User input will be especially helpful in guiding the priorities for these developments.

Session 62: Workshop on the Future of Antarctic Astrophysics - II
Topical, Oral Session, 2:00-5:30pm
Presidio

62.01

Submillimeter Spectroscopy of Hydride Molecules

T. G. Phillips (Caltech)

Simple hydride molecules are of great importance in astrophysics and astrochemistry. Physically they dominate the cooling of dense, warm phases of the ISM, such as the cores and disks of YSOs. Chemically they are often stable end points of chemical reactions, or may represent important intermediate stages of the reaction chains, which can be used to test the validity of the process. Through the efforts of astronomers, physicists, chemists, and laboratory spectroscopists we have an approximate knowledge of the abundance of some of the important species, but a great deal of new effort will be required to achieve the comprehensive and accurate data set needed to determine the energy balance and firmly establish the chemical pathways. Due to the low moment of inertia, the hydrides rotate rapidly and so have their fundamental spectral lines in the submillimeter. Depending on the cloud geometry and temperature profile they may be observed in emission or absorption. Species such as HCl, HF, OH, CH, CH^+, NH_2, NH_3, H_2O, H_2S, H_3O^+ and even H_3^+ have been detected, but this is just a fraction of the available set. Also, most deduced abundances are not nearly sufficiently well known to draw definitive conclusions about the chemical processes. For example, the most important coolant for many regions, H_2O, has a possible range of deduced abundance of a factor of 1000.

The very low submillimeter opacity at the South Pole site will be a significant factor in providing a new capabilty for interstellar hydride spectroscopy. The new species and lines made available in this way will be discussed.

62.02

Molecular Gas in the Magellanic Clouds

F. P. Israel (Sterrewacht Leiden)

We discuss the properties of dense interstellar clouds in the low-metallicity environment of the Magellanic Clouds, based on CO, C^+ and infrared observations. In this environment, radiation dominates the physical processes, leading to a significant variety in the appearance and properties of the molecular cloud complexes. The importance of high-freqency observations possible from Antarctica will be put in the context of using Magellanic Cloud conditions as a template for observations of star-forming galaxies at high redshift.

62.03

Shocking Changes to Molecular Clouds

Gary J. Melnick (CfA)

Supersonic motions are commonly observed in molecular clouds as evidenced by larger-than-thermal line widths measured in most species. The shocks that ensue can profoundly effect these clouds, not only dynamically, but chemically. Because shocks compress and heat the gas, chemical reactions that are extremely slow at typical molecular cloud temperatures ($T \sim 10-30$ K) can proceed rapidly in the wake of a shock. In many cases, compositional changes brought on by a passing shock can endure long after the gas has cooled and returned to its pre-shock state. We have used a coupled time-dependent chemical and dynamical model to investigate the lifetime of such chemical relics in the wake of non-dissociative shocks. Using a Monte Carlo cloud simulation, we explore the effects of stochastic shock activity on molecular gas over a cloud lifetime. Particular attention is paid to the chemistry of H_2O and O_2, two molecules which are predicted to have abundances that are significantly affected by shock-heated gas. Both pure gas-phase and gas-grain chemistry are considered. In agreement with previous studies, we find that shocks with velocities in excess of 10 km s^{-1} can chemically process all oxygen not locked in CO into H_2O on timescales of a shock passage time ($\sim$ few hundred years). For pure gas-phase models, the high water abundance lingers for $\sim (4-7)\times 10^5$ yr, independent of the gas density. A density dependence for the lifetime of H_2O is found in gas-grain models as the water molecules deplete onto grains at the depletion timescale. We demonstrate that the time-averaged abundance of H_2O and O_2 (as well as other tracers, such as SiO and CH_3OH) is a sensitive function of the frequency of shocks. As such, the abundance of H_2O, and to a lesser extent O_2, can be used to trace the shock history in molecular clouds. Equally important, we find that depletion of shock-produced water onto grains can be quite large and is comparable to that observed in molecular clouds. This offers an alternative method to create water-ice mantles without resorting to grain surface chemistry. Observationally, a combination of space-based (for H_2O and O_2) and ground-based (for SiO, CH_3OH, and others) telescopes will be needed to investigate these predictions.

62.04

Infrared Astronomy and Star Formation from Antarctica

M. G. Burton (UNSW)

The Antarctic Plateau provides the pre-eminent conditions on the Earth for wide-field imaging at thermal infrared wavelengths. From 2.2 to 20 microns there are reductions in the sky background of between 20 and 100 times (depending on wavelength) from temperate latitude sites. The site seeing is also of a quite different nature, being confined almost entirely to the lowest 100m of the atmosphere, resulting in larger isoplanatic angles and coherence times for the seeing cells. Such conditions open up the possibility of deep observations in the thermal IR that simply cannot be conducted from any other ground based site. Of particular interest will be wide-field surveys of star formation regions, such as the following:

Line imaging of embedded HII regions along the galactic plane in the Br-alpha (4.05um), PAHs (3.28um) and H2 Q-branch lines (2.42um), to study the environment of the ionized, neutral and molecular mediums of massive star forming regions.

Complete population censuses of the embedded populations of star forming clouds in the L (3.8um) band, both in our Galaxy and in the Magallenic Clouds, utilising the improved sensitivity to disk emission for identification.

Imaging of the most deeply embedded protostars in the mid-IR, from 10-30um.

The star formation history of the Universe through complementary deep L and M (4.5um) band imaging to the HDF-S. These would be sensitive to particularly red galaxies at high redshift; for instance an E/S0 galaxy at z=1.4 has an (unreddened) V-L=10.

We compare the sensitivity of such surveys from Antarctica with those from mid-latitude sites, and propose a 2.5m telescope, SPIRIT, which would be able to achieve unique new science at relatively low cost, complementing the research programs of the new generation of 8m class telescopes.

62.05

Studies on Cloud Structure with a 10m SP submm telescope

R. Güsten (MPI für Radioastronomie)

The scientific potential for studies on cloud structure and star formation with a 10m submillimeter telescope at the South Pole is discussed. Because with the much improved performance of current submm instruments (and in view of future advanced bolometer and heterodyne array detectors), the dynamic range of ground-based submm observations is restricted by atmospheric transmission and its temporal fluctuations. South Pole's exceptionally good and stable transparency in the submm atmospheric windows will permit large-scale mapping and deep integration projects with sofar unmatched sensitivity and calibration accuracy. We will exemplify the scientific perspectives with a few highlights like

• unbiased continuum surveys (@ 350μm for best sensitivity) of nearby molecular clouds to identify dense cores as potential sites of future star formation. Complementary submm polarimetry to reveal magnetic field structure and spectral line follow−ups to study velocity field.

• mapping the fractal structure of clouds in, e.g., the fine−structure transitions of neutral carbon, to complement column density tracing lower rotational CO data.

• investigation of the thermal balance of the interstellar medium as seen in important cooling lines like CI, NII and the excited CO transitions—both from large−scale emission regions like the Galactic center and from more localized PDR's.

62.06

Ultraluminous Infrared Galaxies

D. B. Sanders (University of Hawaii)

The luminosity function for infrared selected galaxies shows evidence for strong evolution for the most luminous objects. IRAS surveys of the local Universe ($z<0.35$) suggest that the co-moving space density of objects with luminosities above $10^{12}L_{\odot}$, increases as $(1+z)^{6-8}$ assuming pure number density evolution, similar to the strong evolution observed for optically selected quasars at similar bolometric luminosities and slightly larger redshifts. Such strong evolution, if continued out to redshifts $z\sim1-4$ would predict a substantial population of ultraluminous infrared galaxies (i.e. $> 10^3$ deg^{-2}) that could be detected in the submillimeter with flux densities $>$ 15 mJy at 450 μm. Recent deep submillimeter obseravtions with the Submillimeter Common User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT) suggest that such a population of high-z objects exists.

62.07

A Submillimeter Survey of Lensing Clusters

Andrew Blain (University of Cambridge)

The advent of a sensitive new submillimeter-wave instrument, the SCUBA bolometer array receiver at the James Clerk Maxwell Telescope, has allowed the first deep images of the distant Universe to be made in this exciting waveband. Galaxies are visible in the submillimeter waveband due to the emission of reprocessed light by interstellar dust grains. Hence, observations in this waveband are complementary to those in the optical. The K-corrections for faint galaxies are large and negative in the submillimeter waveband, and so the selection function of a submillimeter-wave survey is expected to both be flat and extend out to very large redshifts. This has two advantages for a survey of galaxy clusters: i) the lensed images of distant background galaxies are expected to be detectable out to large redshifts and to experience very large magnification biases as compared with optically-selected samples; ii) the flux densities of cluster member galaxies are expected to be smaller than those of the lensed images. The most prominent sources in sensitive submillimeter-wave observations should hence be lensed images of background galaxies. Last summer, Ian Smail, Rob Ivison, Andrew Blain and Jean-Paul Kneib used SCUBA to obtain the first submillimeter-wave images of clusters. The results provided the first observational data on: submillimeter source counts; source confusion expected in future surveys; and the processes of formation and evolution of dusty galaxies. The capability and number of submillimeter-wave telescopes is going to grow very substantially in the next few years, and the sample of about 30 lensed galaxies detected by Smail et al. will be expanded greatly. The excellent atmospheric transmission and low ambient temperature in Antarctica makes it an ideal site for progress in submillimeter cosmology. I discuss what we have learned from the very first surveys of lensing clusters, and describe the exciting prospects for the future.

62.08

Formation and Evolution of Luminous IR Galaxies

Carol J. Lonsdale (IPAC, Caltech and JPL)

In the local universe about 40% of the energy density of galaxies emerges longward of a few microns, and recent COBE detections of the cosmic infrared background indicate that an even larger fraction of the total energy density of galaxies, integrated over the history of the universe, emerged in the infrared to submillimeter wavelength region. Thus while outstanding advances in the measurement of the history of the UV energy density of the universe out to redshifts past 3 have occurred in the last couple of years, we cannot understand the full history of star formation without detailed, deep, observations in the critical IR and submillimeter bands. I will review models for the formation and evolution of galaxies that are luminous at IR and submillimeter wavelengths, and compare them to IRAS and ISO number count data and the COBE CIB measurements, and to popular galaxy formation scenarios. I will highlight constraints on these scenarios imposed by the huge body of work available from deep optical, UV and IR studies, including the popular star formation rate history diagrams based on UV measurements, and studies of damped Lyman alpha absorbers. I will summarize the limits on the star formation rate history at z>3 allowed by the available data and the CIB and suggest avenues for observational solutions to some of the outstanding questions. One of the most exciting tools for investigating the star formation history of the z>1-2 universe will be to exploit the very strong, broad mid-infrared features (the 'unidentified IR bands') which can act as powerful redshift 'filters' and photometric redshift estimators.

62.09

Formation and Signatures of the First Stars and Quasars

Z. Haiman (Harvard University)

We will discuss various observable signatures of the first generation of stars and low-luminosity quasars, including the metal enrichment, radiation background, and dust opacity and emission they produce. To estimate the history of formation of dark-matter halos, we use an extension of the Press-Schechter formalism, incorporating the effects of pressure and molecular hydrogen dissociation. We then use the observed C/H ratio at z=3 in the Lyman-alpha forest clouds, to obtain an average the star formation efficiency in these halos. Similarly, we adjust the efficiency of black-hole formation, and the shape of quasar light curves to match the quasar luminosity function between redshifts z=2-4, to obtain the luminosity function of faint quasars at high redshifts.

We find that in a Cold Dark Matter models, either stars or quasars are expected to reionize the intergalactic medium at redshifts z=10-20. The corresponding damping of CMB anisotropies on small angular scales is 10-20%, detectable by future satellites such as MAP and the Planck Surveyor. We also find that the Next Generation Space Telescope will be able

to directly image about 1-100 star clusters per square arcmin from redshifts above z=10, and a comparable number of faint quasars. However, we show that the lack of faint point sources in the Hubble Deep Field places a mild constraint on the models. The amount of dust produced by the first supernovae have an optical depth of 0.1-1 towards high redshift sources, and the reprocessed UV flux of stars and quasars distorts the CMB by a y-paramater comparable to the COBE limit, y=1.5e-5.

62.10

Submillimeter Extragalactic Observations from the South Pole

Jonas Zmuidzinas (Caltech)

The South Pole offers excellent atmospheric conditions for submillimeter astronomy. In particular, the small values of precipitable water vapor, the low atmospheric temperature, and the excellent atmospheric stability should allow sensitive background–limited bolometric observations in the 350 and 450 μm windows. I will discuss the potential of such observations for studying dusty high–redshift galaxies, similar to those which have recently been detected with the SCUBA instrument on the JCMT, and will discuss the merits of a large submillimeter telescope at the South Pole in comparison to other projects such as the MMA/LSA and FIRST.

62.11

Scientific Context for CMB Anisotropy Observations

E. L. Wright (UCLA Astronomy)

The anisotropy of the Cosmic Microwave Background provides a wealth of information about the initial state and subsequent evolution of the Universe. The primary anisotropies, present at the time of recombination only 300,000 years after the Big Bang, provide information about the primordial perturbation power spectrum for angular scales larger than the horizon at decoupling ($\theta > 2°$), and further information about the modification of this power spectrum by the interactions with matter at angular scales from $\theta = 1°$ to 0.06° (from the Doppler peaks to the thickness of the last scattering surface). Secondary anisotropies produced by non-linear matter density perturbations after recombination extend to even smaller angular scales and can have either a thermal spectrum (ΔT) or a Sunyaev-Zeldovich spectrum (Δy). The Microwave Anisotropy Probe (MAP), to be launched in 2000, will measure ΔT and its polarization for angular scales $\theta \geq 0.21°$, but further ground-based, balloon-borne, and space-borne (PLANCK) observations will be needed to provide better polarization sensitivity, measurements of the Δy anisotropy, and sensitivity to smaller angular scales. Observations from the South Pole can provide the short wavelength data needed for the determination of Δy and the large telescopes needed for small angular scales, and will provide a powerful test of cosmological models.

62.12

Prospects for Measuring the Peculiar Velocity Field of Distant Clusters Via the Kinetic Sunyaev-Zeldovich Effect

A. E. Lange, S. E. Church (Caltech), W. Holzapfel (U. Chicago)

The peculiar velocity field of galaxy clusters offers, in principle, a direct probe of the matter distribution in the universe. The precision with which the peculiar velocity of clusters can be determined using conventional astronomical techniques decreases with the distance of the cluster. In contrast, mm-wave observations of the Sunyaev-Zeldovich (SZ) distortion to the spectrum of the Cosmic Microwave Background (CMB) along the line of sight through the cluster provide a direct measure of the velocity of the cluster relative to the CMB rest frame with a precision that is independent of redshift, and thus promise to sample the peculiar velocity field over a large volume of the universe. Measurements made to date at the CSO on Mauna Kea have been limited by atmospheric noise to a precision of approximately 700 km/sec. The South Pole offers a far superior site for this work. An interesting survey of peculiar velocities could be accomplished using the existing Viper telescope. A 10 m telescope would allow even high redshift clusters to be resolved, and thus reach the ultimate limit of precision set by confusion with intrinsic CMB anistropy.

62.13

Stability of the South Pole Atmosphere at Centimeter Wavelengths

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The stability of the atmosphere at the South Pole has been characterized at cm-wavelengths by analyzing data taken during 2 months of the 1996 - 1997 austral summer by the Python telescope. Python is a single dish swept beam Cosmic Microwave Background (CMB) experiment which operates in the frequency range of 37-45 GHz. It has two separate pixels on the sky separated in azimuth by 2.8°. The covariance between data from the two pixels is taken for portions of the sweep in which they overlap on the sky, thus separating atmospheric fluctuations from instrument noise. It is found the the South Pole atmosphere is bimodal in nature, with long periods of high stability. The polar site is compared with the Atacama Desert, Chile, using data from the NRAO site testing interferometer and assuming a Kolmogorov model for atmospheric turbulence.

62.14

Searching for Distant Clusters with the Sunyaev-Zeldovich Effect

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The Sunyaev-Zeldovich (SZ) effect has become powerful tool for studying X-ray and optically selected galaxy clusters. The unique spectra of this effect allows it to be separated from sources of confusion including foregrounds, lensed background galaxies, and primary CMB anisotropies. In practice, this requires observations at several mm wavelengths. In a low density universe, structure exists back to a redshift of $z \approx 1/\Omega_0 - 1$. Given the locally observed density of galaxy clusters, it is possible to use SZ source counts to constrain cluster formation and evolution. The SZ surface brightness of a given cluster is independent of its redshift. So long as the cluster is well matched to the beam of the telescope, the efficiency of detection will be independent of redshift. The detected clusters can then be followed up with pointed X-ray satellite and optical observations. Efficient cluster searching requires a multifrequency array at mm wavelengths and a telescope of ≥ 2 m aperture. The high transmission and stability of the atmosphere at the South Pole provides unique advantages for observations of the CMB at mm wavelengths. I will discuss the prospects for carrying out this program with the existing 2 m Viper and the proposed 10m telescopes.

62.15

Measuring Polarization in the CMBR from Antarctica

J. Ruhl (UC Santa Barbara)

The cosmic microwave background radiation is expected to be slightly polarized, with variations on a variety of angular scales. Measuring this polarization will complement planned temperature-anisotropy observations. Detector technology has advanced to the point where such polarization measurements are feasible; the case for making these observations from Antarctica will be discussed.

62.16

Very High Energy Gamma-Rays and Neutrinos from AGN

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The AMANDA experiment and its proposed extension called ICECUBE are being built and planned to search for astrophysical sources of neutrinos and gamma-rays, particularly in energy range above 1 TeV. Gamma-rays in the 1 to 10 TeV range from three BL Lac objects have already been detected