

sensitivity maxima, at $\lambda 4000$ and $\lambda 8000$; the color equivalents have been estimated from the ratio of the densities of the two spectral regions. The long base line makes the two maxima very sensitive to color differences, permitting an eye estimate of the color equivalent. The method differs from previous ones in that no photometric measurements are necessary.

Eleven color equivalent divisions can be estimated from the spectra, with a standard deviation in the predicted International CI of 0.14 mag.; the error of estimate of the color equivalents from one plate is about ± 0.05 mag. (m.e.). The chief cause for the scatter in the calibration curve is thus a cosmic one. The relatively low accuracy of this method is offset by the lack of zero point and other photometric errors, as well as its speed.

The photographic limiting magnitude reached in 60 min. is about 14.8 for early stars and 15.2 for late stars. The color equivalents for the three Selected Areas were determined from three 60 min. plates. For S.A. 37 and S.A. 85 a definite trend is evident in the dispersion of proper motions as a function of color equivalent. S.A. 38, which is 10° closer to the galactic plane, gives a discordant variation which is probably due to an increased amount of reddening. This is indicated by color equivalent frequency curves, which show a shift toward the red in the maximum frequency.

Hitherto no separation has been made for the faint stars of the *Radcliffe Catalogue*, for which most are fainter than the limit of objective prism material. The present technique permits an analysis of this proper motion data at intermediate and high galactic latitudes for different color equivalents. The results of this preliminary survey indicate the value of this type of investigation of faint proper motion stars.

1. A Method for Determination of Stellar Magnitudes and Colors, *Medd. Astr. Obs. Upsala*, No. 99, 1949.
2. Determinations of Color Classes for 204 Stars of Large Proper Motion, *Ap. J.* **116**, 587, 1952.

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Baton Rouge, La.*

Young, Richard D. The thermal component of the radio frequency radiation from the sun.

The thermal component of the radio frequency radiation from the sun is derived from the laws of classical physics.

With the velocity distribution method of the kinetic theory of gases the mean number of collisions per second between the particles is found. From this, using Maxwell's equations, the index

of refraction and the coefficient of absorption is obtained. For the intensity of the emitted radiation the equation of transfer is solved in a three dimensional refracting and absorbing medium. The path of the rays is found from the equation of the iconal of geometrical optics in an absorbing and refracting medium. The solution obtained does not exhibit the phenomenon of total reflection, as is present in purely refracting matter.

Numerical calculations give the distribution of the radiation across the solar disk from 30 Mc through 3000 Mc. At 3000 Mc the sun is of nearly uniform brightness with a bright sharply defined limb. At lower frequencies the central portion becomes brighter than the rest and the limb diffuse. The integrated solar intensity agrees quite well with experimental evidence.

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Zwicky, F. Species of cosmic matter.

It has been known for a long time that different species of stars and of matter in general are found in various locations of the universe such as in the neighborhood of the sun, in galactic and in globular clusters, in spiral and in elliptical galaxies and so on. Different species of the common stars as well as special objects such as certain variables, novae and supernovae, B-emission stars, Wolf-Rayet stars, emission nebulae, gas and dust clouds often seem to be grouped in both real space and in "velocity space." In order to characterize the totality of species in any location one has generally resorted to the representation of stars in Hertzsprung-Russell diagrams or more generally in color diagrams which give the spectral type or color as functions of the absolute or apparent magnitudes. Also the idea has been advanced that fundamentally there are only two types of populations, I and II, and mixtures thereof. In contradistinction to these views, a morphological study of the known large-scale interactions of matter suggests 1) celestial objects can organically be arranged only in multidimensional spaces of representation rather than in two dimensional diagrams. Absolute magnitude, color and spectral characteristics (more than one), period and amplitude of light variation, flare characteristics, large-scale magnetic and electric fields, close association with other bodies, dust and gases must be introduced as the independent coordinates in a representative space. 2) There exists a great number of different stellar and material populations.

The morphological conclusion 1) is now being checked by a thorough study of the characteristics of especially the fainter stars in galactic clusters such as the Hyades. While much work will be necessary to establish true morphological arrays of stars in lieu of the two dimensional diagrams, decisive observational evidence is already at hand that the concepts of stellar populations I and II are entirely inadequate. A most striking example of the coexistence of at least three distinct stellar populations was obtained on excellent photographs with the 200-inch telescope of the Whirlpool nebula. These populations are characterized as follows: a) blue patches showing resolved blue stars (supergiants), b) red patches which are not resolved, c) very extended smooth blue patches which show no resolution into stars or groups of stars whatsoever and which are particularly prominent in the outskirts of the companion nebula NGC 5195 and along the faint broad spiral arm which connects NGC 5194 and 5195. As we shall proceed to include ever fainter stars in our population studies we may expect to discover a great number of basic populations. The facts already known at present, suffice to indicate that any evolutionary theories based on the assumption of two-dimensional population diagrams are likely to be lacking any realistic foundation. Likewise, any distance determinations among distant galaxies which are based on the assumption of only two stellar populations and which rely on such criteria as luminosities of brightest stars, clusters of stars and variable stars will be found to be equally unrealistic.

In connection with these investigations a simple but powerful method of composite "red" and "blue" photography has been developed which on the resulting plates shows extended blue and red objects respectively lighter and darker than the sky background while blue and red stars appear respectively as dark points with light rings around them or simply as dark points.

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TITLES OF ADDITIONAL PAPERS PRESENTED AT THE MEETING IN BOULDER, COLO.

- Arp, Halton C. Color-magnitude arrays for seven globular clusters.
 —. Period-luminosity relation for type II Cepheids.
 Babcock, Horace W. and Harold D. Recent magnetic observations of the sun.
 Bell, Barbara. The emission-line corona and the solar activity cycle.
 Brown, Richard. Motions in the envelope of R Coronae Borealis.
 Burbidge, Geoffrey and Margaret. The magnetic star AF Pegasi.
 Carpenter, E. F. and W. S. Fitch. The Steward Observatory program of times of minimum of eclipsing variables.
 Clemence, G. M. and Dirk Brouwer. The known integrals as a test of the numerical integration for the five outer planets.
 Cook, Allan F. On the theoretical interpretation of meteoric spectra.
 Cook, Allan F. and Peter M. Millman. Photometric analysis of a spectrogram of a Perseid meteor.
 Cox, Arthur N. A study of the galactic cluster NGC 2287.
 Davis, Leverett, Jr. The alignment of galactic dust by motion through a gas.
 Gaposchkin, Sergei. The double-line eclipsing system ZZ Bootis.
 —. The light-curves of Nova Monocerotis 1942.
 Green, Louis C., Marjorie M. Mulder and Margaret N. Lewis. Some comments on the ground state wave functions for the simplest two electron systems.
 Greenbaum, Irving. Observed and theoretical values of astronomical refraction at low altitudes.
 Greenstein, Jesse L. Spectra of blue stars of low luminosity.
 Greenstein, J. L. and E. Tandberg-Hanssen. The solar abundance of beryllium.
 Herget, Paul. Recent electronic computation of orbits.
 Horak, Henry G. and Charles A. Lundquist. The emitting atmosphere with a linear source distribution.
 Hubble, Edwin P. and Allan Sandage. The brightest irregular variables in M31 and M33; a new class.
 Keller, Geoffrey and Robert H. Hardie. Experimental verification of a recently proposed theory of astronomical seeing.
 Kraus, John D. Radiation from the galaxy and supergalaxy at 250 megacycles per second.
 Kron, G. E. and Howard S. White. Application of Continental Electric Co. photocells to 6-color photometry.
 Kron, Katherine G. RT Andromedae, a peculiar dwarf eclipsing variable system.
 Krook, Max. On the moment method of solution of transfer equations.
 Larmore, Lewis. Study of solar prominence motions.
 McVittie, G. C. Aerodynamic motions of interstellar gas clouds.
 Markowitz, William. The dual-rate moon position camera.
 Matsushima, S., R. N. Thomas and C. A. Whitney. Departures from thermodynamic equilibrium and self-absorption in the Balmer line spectrum from the 1952 eclipse.
 Meinel, A. B. Aspheric field correctors for astronomical telescopes.
 Menzel, Donald H., Max Krook and Richard N. Thomas. A magneto-hydrodynamic model of solar prominences.
 Mills, B. Y. Radio brightness distributions across four discrete sources of cosmic noise and comparisons with their associated nebulae.
 Munch, Guido. Galactic structure and the distribution of interstellar gas.
 Nail, Virginia McKibben, Charles A. Whitney and Campbell M. Wade. Nebulosities of the Small Magellanic Cloud.
 Nassau, J. J. and Donald Cameron. Objective prism spectra of long-period variables in the near infrared.
 Roach, Franklin E. The zodiacal light and the F-component of the corona.
 Sandage, Allan R. The luminosity function to absolute magnitude + 7 in the globular cluster M3.
 Seyfert, Carl K. The Arthur J. Dyer Observatory of Vanderbilt University.
 Stebbins, Joel and Gerald E. Kron. The pulsating star β Cephei.
 Van Wijk, Uco. The origin of the high-velocity stars.
 Whipple, Fred L. Photographic meteor orbits and their distribution in space.

REPORTS OF OBSERVATORIES, 1952-1953

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Thaw Refractor. Observing conditions during the time of the U. S. Synoptic High Altitude Gust Program were typical of those throughout the year. Two of the three nights were cloudy and on the third the seeing was poor. March was the worst March and April the worst April in the 39 years of the use of this telescope. However, the 316 plates obtained in September made that the best September since 1922.

Altogether 1456 plates were taken on 132 nights. The averages over the last ten years are 1760 and 155 respectively. Observations were made during 119 evenings and 73 mornings. Both evening and morning observations were made on 60 nights. Observers were Wagman, Rachuba, Winterhalter, Gratz, Schwartz and since March Robert F. Kemper.

All but five of the plates during the year were for the parallax and double-star programs. The number of plates measured was 1466. A list of 52 parallaxes was published (*A.J.* 57, 123, 1952).

Near the end of this report year measures by Mrs. Crissman revealed a perturbation in the star Ross 52, $14^{\text{h}}49^{\text{m}}5$, $+23^{\circ}58'$, (1900). This star is about two inches off center on plates of BD $+23^{\circ}2751$ which has been observed since 1927. There were 48 plates measured in right ascension through 1952. The resulting parallax is $+".109 \pm ".011$. Orbit corrections based on a curve of the residuals changed the result to $".112 \pm ".007$. The parallax for the BD star is $+".034 \pm ".006$.

The half range of the curve of residuals of the Ross star is $".09$ and the period 20.5 years. No certain elongation of the images appears on the plates. It was therefore somewhat surprising to find that the star had been measured as a double star with a separation of $0".9 \pm 0".1$ on McCormick plates with the companion about 0.6 magnitude fainter than the primary (*Pub. A.S.P.* 53, 119, 1941). Kuiper gives 11.5 for the visual magnitude on the basis of its being a single star (*Ap. J.* 92, 126, 1940). Assuming $.38 \odot$ as the mass of the primary and a difference of 0.75 magnitude photographic between the components, we find a minimum mass $.10 \odot$ for the companion.

The number of white dwarf stars on the parallax program has been increased from 29 to 55 during the year. The faintest is magnitude 15.4,

requiring a thirty-minute exposure on a 103a-O plate.

Spectrographic Laboratory. Dr. Burns has continued his work on the determination of precise wave lengths and the search for standards in the shorter waves with the collaboration of Kenneth B. Adams of the Westinghouse Electric Research Laboratory. James C. Hunter, Jr. and Mrs. Jean Longwell, part time, have assisted in the program.

Since January 10 a vacuum chamber, designed and built by Adams for the Fabry and Perot interferometer, has been in use.

Wave lengths of copper from 6600 to 3200 Å are in manuscript and preliminary results have been obtained in the region 3200-2138 Å. Observations of the hollow cathode spectrum of Cu II are planned for obtaining standards in the Schumann region. Work on the isotope, Cu 63, is in the experimental stage.

The cadmium spectrum from 6438 to 3133 Å has been observed with a Beese lamp. The wave lengths of 21 lines and the corresponding levels are in manuscript. Preliminary work has been done in the region 3261-2144 Å. The isotope, Cd 114, has been partly observed in the region 6438-2144 Å using a special lamp operated by an oscillator. The region 6438-2288 Å has been observed using a Michelson tube held to a two-degree temperature range. A mercury tube shines through the Michelson tube to provide a comparison of the two spectra.

Results for 234 lines were published in the article "Energy Levels and Wavelengths of the Isotopes of Mercury-199 and -200" by Kevin Burns and Kenneth B. Adams in the *J. Opt. Soc. Amer.* 42, 716, 1952. Results for about 250 lines of A I by the same authors are in the hands of the printers.

Miscellaneous. The one-prism Mellon spectrograph is to be reconditioned before it is replaced on the Keeler 31-inch reflector.

Kiewiet de Jonge has continued his investigations in statistical astronomy and will present his results in forthcoming papers.

Instruction. A total of 34 students took the two introductory astronomy courses taught by Kiewiet de Jonge and Wagman. Kiewiet de Jonge also had a student in celestial mechanics one semester.

There were 2479 evening visitors on the 116 nights of the Frick Public Evening Service. Of these 435 came to the August 2 Open House to