the Case system of classification of M stars, the $B-V$ colors remain approximately constant at about 1.55 from class M0 to M5, and then increase with advancing spectral class to 1.90 at M7. The $V-I$ colors increase more or less uniformly with advancing spectral class from about 1.10 at M0 to 5.30 at M9.

This study has been supported by the Office of Naval Research.

Line Intensity Ratios in the Orion Nebula.

PETER B. BOYCE, *The University of Michigan*.—Observations have been made of the intensities of $H\alpha$, $H\beta$, and $H\gamma$ as a function of position in the Orion Nebula using a photoelectric spectrophotometer attached to the University of Michigan 24-inch Cassegrain reflector. The areas sampled were one minute of arc square and the effective resolution of the system was 18 Å. An EMI 9558 QA tri-alkali photocell was used and has proved to be very stable. The output of the photocell was amplified by a General Radio 1230A amplifier and displayed on a Brown recorder. In addition to scanning, data were taken using the instrument as a narrow-band photometer to measure the intensities of the lines above the continuum.

The observed line ratios show very good agreement with the theoretical ratios as modified by a $1/\lambda$ absorption law. Self-absorption is definitely negligible. The color excesses of the Balmer lines increase toward the center of the nebula suggesting that the dust is contained within the nebula. In this case the amount of dust cannot be directly obtained from the reddening, since, for a given quantity of dust, the amount of reddening is a strong function of the way the dust is distributed.

Absolute intensities have also been obtained which show the nebula to be quite radially symmetric. At 0.8, 1.2, and 3.7 min of arc from θ' Ori C the surface brightness in $H\beta$ is 0.050, 0.026, and 0.0047 erg/cm² sec sr, respectively. These values are accurate to within 5%. The total flux in $H\beta$ uncorrected for absorption is 7.1×10^{-8} erg/cm² sec $\pm 10\%$.

Condensations in the Intergalactic Medium. E.

M. BURBIDGE, G. R. BURBIDGE, AND F. HOYLE, *University of California, San Diego*.—This paper is concerned with the properties of peculiar galaxies and consideration of the question as to whether some of these galaxies are of recent origin; i.e., whether they have evolutionary ages $\ll H^{-1}$. The steady-state theory requires new galaxies to form. In the cosmological discussion it is shown that within the framework of the theory there is no requirement for galaxies to form continuously at a constant average

rate, but there must be epochs of condensation of new galaxies. This is a difference between the mathematical form of the steady-state theory and the form based on the perfect cosmological principle of Bondi and Gold.

A discussion is given of all the factors which must be considered—form, internal motions, spectra, colors, and amounts of uncondensed material—when one attempts to determine whether some galaxies have recently condensed. Finally, observational evidence on a small sample of peculiar galaxies within 100 Mpc is described. The evidence appears to be consistent with the requirements of the steady-state theory in the form described earlier, although we do not believe that it is established beyond doubt that new galaxies are being formed.

Hydrogen Motions in M31. B. F. BURKE, K. C.

TURNER, AND M. A. TUVE, *Carnegie Institution of Washington*.—The Andromeda Nebula M31 was studied with the 300-ft transit telescope of the NRAO at Green Bank, West Virginia, using the Carnegie multichannel H -line spectrograph. Preliminary reduction of the data show that: (1) 10' of arc from the nucleus along the minor axis residual expansion is less than 2 km/sec. (2) The hydrogen observed along the major axis is markedly asymmetrical. There is good agreement along the north-following half of the major axis between hydrogen concentrations and Baade's bright star arms N4, N5, and N6. Along the south-preceding half the agreement is poor for all except arm S7. (3) There is good agreement between van de Hulst's rotation curve and our observations in the outer parts of M31, but within 70' and 40' of the center along the north-following half and south-preceding half, respectively, our rotational velocities appear to be 20 to 40 km/sec smaller. The differences are greater along the north-following half.

Neutral Hydrogen in NGC 6822. JAYLEE BURLEY,

Goddard Space Flight Center.—Observations of the neutral hydrogen radiation at 21-cm wavelength from NGC 6822 have been made using the Harvard 60-ft radio telescope and maser receiver, with a beamwidth of 53 min of arc and a bandwidth of 80 kc or 17 km/sec. Drift curves and declination scans were obtained at velocities ranging from +67 to −152 km/sec.

The radial velocity is found to be −60 km/sec reduced to the sun. Estimates obtained for the mass of neutral hydrogen and for the total mass of the galaxy are 1.4×10^8 solar masses and 1.4×10^9 solar masses, respectively, based on a distance of 480 kpc and an assumed inclination angle of 45 deg. Evidence of rotation is also discussed.

The observations were made at the 1962 Harvard Summer Institute in Observational Astronomy sponsored by the National Science Foundation.

A Possible Interpretation of Schröter's Valley and Other Lunar Sinuous Rilles. WINIFRED SAWTELL CAMERON, *Goddard Space Flight Center*.—The hypothesis that acid magma has been generated on the moon, and that many types of lunar features can be interpreted as manifestations of it, has been proposed in another paper (O'Keefe, J. A., and Cameron, W. S. *Icarus* 1, No. 3, 271–285, 1962). That hypothesis is assumed in this paper. One of the most common terrestrial manifestations is the nuée ardente, typified by the famous Peléean eruptions. It is to be expected that similar events have occurred on the moon. The question is, what lunar features exhibit vestiges of this kind of activity?

Descriptions of the eroding actions of some nuées ardentes from Mont Pelée and Asama Yama volcanoes, given by Perret (Perret, F. A., *Carnegie Inst. Wash. Publ.* No. 458, 1935) and Aramaki (Aramaki, S., *Japan. J. Geol.* 27, 189–229, 1956, Part I), respectively, give a clue as to the form of objects to look for on the moon. In both cases, ditches or furrows have been dug and a sinuous course is sometimes found. The dimensions of these ditches or furrows sometimes reach those that could be detected at the distance of the moon.

A class of features, with certain common characteristics was first pointed out by Pickering [Pickering, W. H., *The Moon* (Doubleday, Page, and Company, New York), pp. 42–43]. These common characteristics of the lunar sinuous rilles are similar to the terrestrial ditches produced by nuées ardentes. It is proposed in this paper that Schröter's Valley and the two more conspicuous sinuous rilles in the Apennines in particular, and perhaps all the very rare sinuous rilles described by Pickering, can be interpreted as the product of erosion by nuées ardentes, which is often comparable to that produced by marine turbidity currents that sculpture some of the submarine canyons on earth.

Nebular Spectrograph of a New Type. E. F. CARPENTER, *Steward Observatory*.—A spectrograph of simple configuration has been successfully used for several years for nebular studies with the 36-inch Steward Observatory reflector. The dispersive element consists of a transmission grating mounted on the hypotenuse of a prism and operates as an echelle with very fine steps between the individual grooves of the echelle. The angle of the prism is selected so that the central wavelength of the spectrograph passes through the system undeviated. As a consequence the spectrograph elements line along

a straight line enabling a simple mechanical system to be constructed. For low-dispersion work the limitation of not being able to change centering of the spectral range is not important.

The spectrograph is used at the $f/5$ Newtonian beam and has a speed of $f/0.8$ with a curved-field Schmidt. Well-exposed spectra on galaxies are obtained in two to six hour exposures. A flat-field modification of the camera is currently being made to circumvent the currently acute problem of obtaining emulsions of high speed and low fog on film base, even though the difficulty of cutting small plates is appreciable in comparison to the ease of cutting film pieces with a small die stamp.

Dynamics of RR Lyrae Envelopes. R. F. CHRISTY, *California Institute of Technology*.—A study is underway of dynamical models of stellar envelopes (radial motion only). The coupled nonlinear, one-dimensional partial differential equations of hydrodynamics and heat conduction are integrated numerically. Convection has been ignored in the heat transport because of the low density of the giant envelopes. The core of the star at temperatures above 10^6 ° is treated as an unmoving constant heat source. The surface boundary has zero pressure and is radiative. An initial velocity distribution is imposed on a static equilibrium solution to initiate a motion approximating the fundamental mode. The integration is followed in time for several periods to identify the characteristics of the motion.

In this way, a number of models similar to RR Lyrae envelopes have been studied. The effect of varying the mass, mean radius, luminosity, and hydrogen-to-helium ratio has been explored in a preliminary way. Models ranging from 20% H , 80% He to 100% H (all with $z=0.002$) and with mean T_e ranging from 5500° to 7500° have been tried.

A number of observable characteristics such as period, velocity, amplitude, luminosity amplitude, phase relation of velocity and light curves, temperature amplitude, radius amplitude, and also details of the shapes of these curves can be correlated with the four parameters above which determine the model. It is hoped that more accurate values of these parameters will result from this work. Already, it is clear that the calculated envelopes of appropriately chosen models have the appearance of actual RR Lyrae stars, including the correct shapes of light and velocity curves and the correct phase relation between them. In particular, the phase relation is sensitive to both hydrogen-helium ratio and to mean temperature. Preliminary conclusions are reported.

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