McDonald Observatory in November and December, 1951, February and March, 1953, and November, 1953. The method was calibrated by measures of about one hundred stars for which accurate spectral classes and luminosity classes by W. W. Morgan were available. The agreement between the two sets of classifications was very satisfactory.

For about seventy F stars, of photoelectric $B-V$ color, indices measured by H. L. Johnson, D. Harris, and by P. Naur at the McDonald Observatory were available. For most of these stars interstellar reddening should be very small so that the accuracy of prediction of intrinsic colors from the measured $H\beta$ and Balmer indices could be tested. The photometric probable error of a predicted $B-V$ value of one observation is ± 0.006 mag. This corresponds to a probable error ± 0.02 of a spectral class. The comparison between observed and predicted $B-V$ values indicated that cosmical scatter was small, of the order of ± 0.006 mag. or less.

The photometric probable error of one observation of a predicted absolute visual magnitude for an F star was found to be ± 0.18 mag. Comparison with absolute magnitudes from spectroscopic and trigonometric parallaxes gave no indication of cosmic scatter.

For the B stars the predicted absolute visual magnitude depends practically only on the $H\beta$ index. The photometric probable error of one observation was found to be ± 0.12 mag. Comparison with spectroscopic absolute magnitudes determined by W. W. Morgan indicated no cosmical scatter. An upper limit only could be determined, viz. ± 0.2 mag.

Photoelectric photometry with interference filters (K line, g discontinuity and cyanogen criteria) of about 250 K stars, carried out by Mr. K. Gyldenkrne with a 10-inch reflector of the Copenhagen Observatory, confirmed the results obtained earlier that two dimensional classification is possible here also. The agreement with classification obtained by W. W. Morgan and by Miss Nancy Roman is satisfactory. Comparison with color indices measured by D. Harris indicated that for K giants the intrinsic color can be predicted from the K-line criterion with a probable error of one observation about ± 0.012 mag.

Simultaneous photoelectric photometry with photon counters of three narrow wave-length regions, $H\beta$ and two comparison regions, defined through slits at the cou spectrograph focus of the 82-inch reflector of the McDonald Observa-

tory, have been carried out. The experience gained indicates that it will be feasible and advantageous to develop the classification method in this direction. What is required of the spectrograph is fairly high angular dispersion, so that the wave length regions are sufficiently well-defined even with a slitless arrangement. While the interference filter method used with the 82-inch yields high precision down to about 12 mag., simultaneous measures would extend the range of application to about 14 mag. For equal precision the gain over the photographic method is about 4 magnitudes when the photoelectric accumulation time is equal to the photographic exposure time.

1. B. Strmgren, *A. J.* **56**, 142, 1951.

*Yerkes and McDonald Observatories,
Williams Bay, Wis.,
and Fort Davis, Tex.*

Whitford, A. E. Observational tests for intergalactic matter.

The observation that distant spiral galaxies are not reddened¹ is evidence against appreciable selective absorption in intergalactic space out to about 100 million parsecs. A gas-dust mixture like that in the solar neighborhood of density 10^{-29} g/cm³ would produce an intergalactic color excess of about 0.10 mag. in such a path length. According to the Oort-van de Hulst analysis,² however, solid particles would be very unlikely in intergalactic space since the required density for condensation exists only inside galaxies. Rayleigh scattering by gas alone would require impossibly high densities to produce detectable reddening. Zwicky's suggestion of absorption effects on background nebulae seen through a cluster of galaxies is not a general test,³ since such a region could show an accumulation of intergalactic gas and dust stripped from spiral systems by the Baade-Spitzer collision mechanism.

Detection of a purely gaseous intergalactic continuum by line absorption is complicated by the red shift. A shallow line whose depth is independent of path length would be expected. For NaI and CaII , a density of the order of 3×10^{-13} atoms/cm³ would produce a 5 per cent depression. If all of the atoms of either type were in the favorable state of ionization, cosmic abundance ratios would set a limit of detection of 5×10^{-31} g/cm³ for the total density. The latter figure is of the same order as the revised value of the smoothed density of nebular matter.

A study of ionization equilibrium is handicapped by uncertain knowledge about the radia-

tion field. Under the assumptions that (1) intergalactic space is an *HI* region, i.e. no radiation of wave length less than .912Å escapes from galaxies, (2) the quality of the radiation is like that found by Dunham for the solar neighborhood, (3) the gas kinetic temperature is 50°K, it is found that the *CaII* would exist in a detectable amount for a total density of 5×10^{-28} g/cm³. Failure to notice absorption on existing spectrograms rules out a density much over 10^{-27} g/cm³, since absorption goes as the square of the total density. The test for *NaI* is about ten times less sensitive.

An expanding intergalactic continuum of density 5×10^{-28} g/cm³ could not be detected as an emitter of the 21 cm hydrogen line, because the red shift would make the portion seen by the receiver band width an optically thin layer. If intergalactic gas in the non-expanding local group of galaxies has a turbulent velocity no greater than the peculiar velocities of the galaxies, about 50 km/sec, then detection of the above mentioned density at a temperature of 50°K should be possible. M 31 could possibly be used as a hot background source for detection of the 21 cm line in absorption.

It may be concluded that detection of an intergalactic density of the order of magnitude predicted by Hoyle's theory of continuous creation is not hopeless, and that a careful observational test seems warranted.

1. A. E. Whitford, *A. J.* **58**, 49, 1953.
2. *M. N.* **106**, 159, 1946.
3. *Physics Today* **6**, 7, 1953.

*Washburn Observatory,
University of Wisconsin,
Madison, Wis.*

Wilson, Raymond H., Jr. and Walter Lee Moore.
An eyepiece interferometer for double star measurement.

The desirability and feasibility of an eyepiece interferometer was called to our attention early in 1951 by a private communication from W. S. Finsen of Union Observatory, Johannesburg, and later by his publication.¹ The Anderson-type interferometer, in use by Wilson at Flower Observatory since 1934, would not be readily adaptable for testing and use on other telescopes. On the other hand, an eyepiece interferometer made to fit in a standard eyepiece tube could, with relatively minor adjustments and calibrations, be used on any telescope having a focal ratio between limits for which the interferometer was designed.

Following the general plan suggested by Finsen, light from the objective enters the present interferometer through a collimating lens 16 mm diameter, 38 mm focal length, focussed in the telescope so as to produce parallel rays from a star. The slits for dividing the beam, cut out of thin brass shim stock, are located at the Ramsden disc (image of the objective) of the collimator. The outer boundary of the slits is a circle having a diameter of 1.9 mm, which would, therefore, be entirely within the Ramsden disc for any objective with focal ratio shorter than $f/20$, provided all centers are coaxial.

The slit mechanism was designed by Dr. Moore, who did the machine work involved on all parts of the interferometer. It consists of 3 plates of thin brass shim stock, in one of which is a fixed punch hole, centered on the optical axis, which always forms the outer boundary of the slits. The inner boundaries are formed by edges of the other two plates, mounted in contact with the first, and each attached separately to two opposite screw nuts which are both engaged to the same screw bolt having opposite threads on each end. Readings of the screw head can thus be calibrated to give the variable separations of the slits, whose inner boundary may be straight or circular, depending on which edge of the movable sheets marks it.

Slits so situated are optically equivalent to similar slits having the full diameter of the objective and located near its plane. They can be freely rotated for proper orientation on a double star, and their position angle is indicated by a vernier pointer on a 3-inch aluminum circle.

After passing the slits, the light from a star is next received by a miniature telescope, through the eyepiece of which the interference pattern may be viewed. Except that its objective must enclose the light cone from the slits, there are no requirements on its construction aside from convenience of size, optical feasibility and sufficient magnification to show clearly the interference fringes. The present instrument has an objective 21 mm in diameter, and slightly over 2 inches focal length. The eye end is a tube capable of delicate focussing adjustment, which holds snugly a standard 1¼-inch tube commercial eyepiece of about ½-inch effective focal length. All optical surfaces of the eyepiece interferometer are coated. The total length of the instrument is about 6 inches.

Tests on several telescopes over ten inches in diameter, including both refractors and reflectors,