strengthened through the action of a magnetic field.

*Whitin Observatory,
Wellesley College,
Wellesley, Mass.*

Whipple, Fred L. Comets and the zodiacal light.

This theoretical paper concerns the maintenance of the zodiacal light and Fraunhofer corona by cometary detritus. Meteoritic particles lost from comets are assumed to spiral into the sun by the Poynting-Robertson effect, disturbed, however, by planetary perturbations. A dynamic equilibrium between the loss of meteoritic material by comets and the loss of the zodiacal cloud to the sun will be attained over long intervals of time.

The time of spiralling according to the Poynting-Robertson effect varies as the ratio of particle mass to area while the light scattered by a particle varies as its area; hence, for a range of particle radii from about the wave length of visual light to the order of one centimeter, the total amount of sunlight scattered by particles lost from comets is proportional to the total mass of the particles and is otherwise independent of their shapes or sizes. An application of these results to the Fraunhofer corona and the zodiacal light as investigated by van de Hulst and Allen indicates that the zodiacal cloud can be maintained by the addition of approximately one ton of meteoritic matter per second.

All the comets, if their nuclei are constructed according to the icy conglomerate model, will together lose some thirty tons of meteoritic material per second. Most of this material will move initially in very long-period orbits with aphelia much greater than that of Jupiter. A theory of the effects of Jupiter's perturbations on the contracting orbits indicates that only a small fraction of such material can cross the "Jupiter gravitational barrier" eventually to spiral into the sun by the action of the Poynting-Robertson effect. It appears that the larger particles, such as those responsible for visual or photographic meteors, will generally be removed by Jupiter's perturbations or encounter. Only very small particles, in the range of diameters below 10^{-2} cm as required for the zodiacal cloud by the theories of van de Hulst and Allen, spiral into the sun sufficiently rapidly to become contributing members of the zodiacal cloud. Direct orbits of moderate inclination will be strongly favored, as for the short-period comets. Near the sun the space

density will vary nearly as the inverse solar distance.

Hence, the icy conglomerate model of comets, coupled with the Poynting-Robertson effect and planetary perturbations, provides the required rate of addition of material to the zodiacal cloud and also predicts the required distribution of particle sizes. Although other sources of the zodiacal light may exist, the cometary source appears to be adequate to maintain the basic zodiacal cloud.

This research has been carried out under a U. S. Naval Bureau of Ordnance contract.

*Harvard College Observatory,
Cambridge, Mass.*

Whitford, A. E., and H. L. Johnson. Color of distant galaxies.

In order to provide additional data for establishing the color-velocity relation reported by Stebbins and Whitford,¹ colors and magnitudes of 10 elliptical galaxies in the Pegasus, Coma, and Bootes clusters have been measured with a 1P21 photomultiplier on the Mount Wilson telescopes. The magnitudes range from 13.1 to 19.3. The new data permit a color comparison between the 4 or 5 brightest galaxies in each cluster, thus providing more homogeneous samples than previously available. The former result is confirmed; the increase in color index is roughly twice that predicted from the red shift. Four-color measures of 7 elliptical galaxies in nearby clusters show a mean energy curve very close to that of M32, which had been used as a typical object in calculating the red-shift reddening.

1. *Ap. J.* **108**, 413, 1948.

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

Wildt, Rupert. New emission lines in M dwarfs.

A number of ultraviolet spectra of K and M dwarfs were obtained with the *Qf/2* camera, dispersion about 65Å/mm at $\lambda 3250$, attached to the spectrograph of the 82-inch McDonald reflector. The exposure times were chosen as long as feasible, in order to record the ultraviolet at wave lengths less than $\lambda 3500$. A cursory inspection of the first exposure of the star BD +20°2465 (dM4e) revealed 3 emission lines below $\lambda 3300$, where the continuum of the star had already faded out; their existence was confirmed by a second exposure. Bright lines of *H*I and *Ca*II had been noticed in this star by Swings and Struve,¹ and recently it has become famous