

(From Lowell Bull. 4, 300, 1960)

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Measurements of the Wave Length Dependence of Polarization

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I would like to discuss briefly four types of wave length dependence of polarization. The first type, encountered in the solar system, is shown in Figure 1. Percentage polarization is plotted against λ^i . We have infrared, red, green, blue, and ultraviolet filters, and a nickel sulfate filter with effective wave length at 3250A. The filter data have been published (1) together with a description of the photometer. The results are based on a series of color - phase and polarization - phase observations for seven small regions of the lunar surface; an example is shown in Figure 2. The wave length dependence of Figure 1 is found for the moon, for Mars and Mercury and also for Venus (2).

As a part of a balloon project of the Office of Naval Research we are planning to take the photometer above the ozone layer, to 115,000 feet, and to extend the measures into the ultraviolet and make observations at 2200A, 3000A, and perhaps also at 2600A. We are looking for a turnover in the curve of Figure 1, a maximum at still shorter wave lengths. If the polarization is caused by particles, we may be able to determine particles sizes from the wave length at which the turnover occurs.

The second type of wave length dependence is that found for interstellar polarization. It is shown for two stars in Figure 3. When the results for eight stars, at different galactic longitudes, are normalized at about 6500A, it is found that the amounts in the infrared and in the ultraviolet are nearly the same. Calculations of the wave length dependence of the interstellar polarization have been made by van de Hulst and Elske Smith for aligned cylindrical particles of various refractive indices. The agreement between observations and theory is equally good for metallic and dielectric particles; the diameters are near 0.05 and 0.3 microns respectively.

The third type of wave length dependence is that found in reflection nebulae NGC 7023 and NGC 2068. This is very tentative and I want to make more checks before publishing the detailed results. One must correct for sky brightness extremely carefully in order to avoid systematic errors. We are presently making detailed observations in a few reflection nebulae at different phase angles. With the Mie theory we will try to obtain particle sizes and refractive indices from the observations.

A fourth type of wave length dependence was found by Ohman (3) for the solar corona. There actually is no change with wave length; it would be illustrated by a straight horizontal line in Figure 1. Ohman has explained his observations as the result of scattering by free electrons. I suppose one could make similar predictions, of no-wave-length-dependence, for electron scattering in eclipsing early-type stars and for synchrotron radiation.

The polarization-wave length dependence is a powerful tool. Another example is in the case of the zodiacal light with the controversy as to whether the zodiacal light is caused by particles or electrons. The wave length dependence, if it can be observed, may give the answer to this question. In the observations one must correct carefully for sky brightness especially since, near sunset and sunrise, the sky itself is strongly polarized. On the basis of what we tried, I believe it can be done with a fast-moving telescope such as the 36-inch at McDonald.

References

1. Gehrels, T. and Teska, T. M., F.A.S.P., Feb. 1960
2. Gehrels, A.J., 64, 332, 1959.

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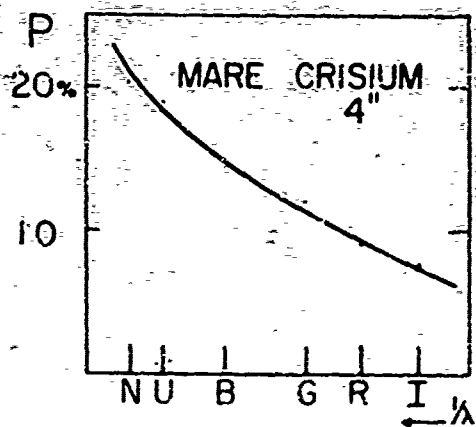


Figure 1. Percentare polarization as a function of the reciprocal of the wave length. A diaphram of 4" diameter was used on Mare Crisium. The observations were made near quarter phase at effective wave lengths 9900 (I), 6836 (R), 5600 (G), 4200 (B), 3590 (U), and 3250 (N) Angstroms.

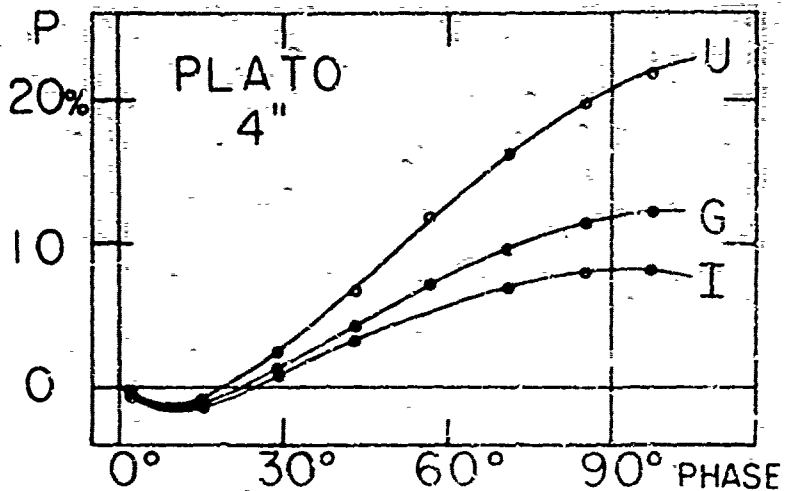


Figure 2. Percentare polarization as a function of phase for a small region within the lunar crater Plato. Observed with the McDonald 82-inch telescope, April 17 - 24, U.T., 1959, with Ultraviolet, Green, and Infrared filters.

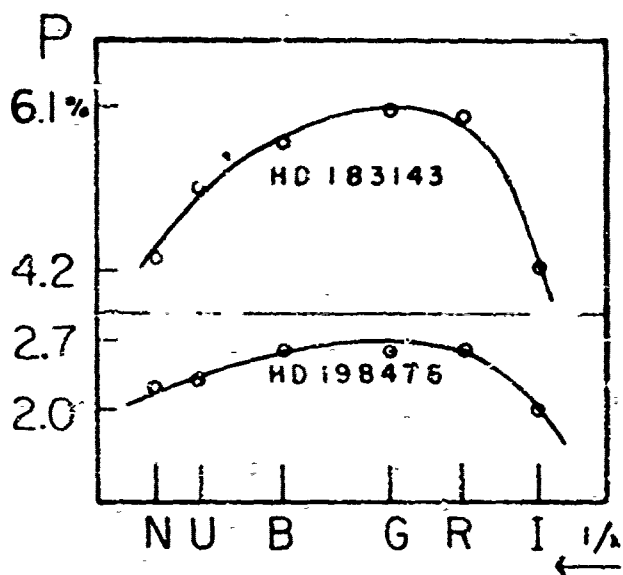


Figure 3. Polarization as a function of the reciprocal of the wave length. Observations of interstellar polarization on HD 183143 and HD 198475.

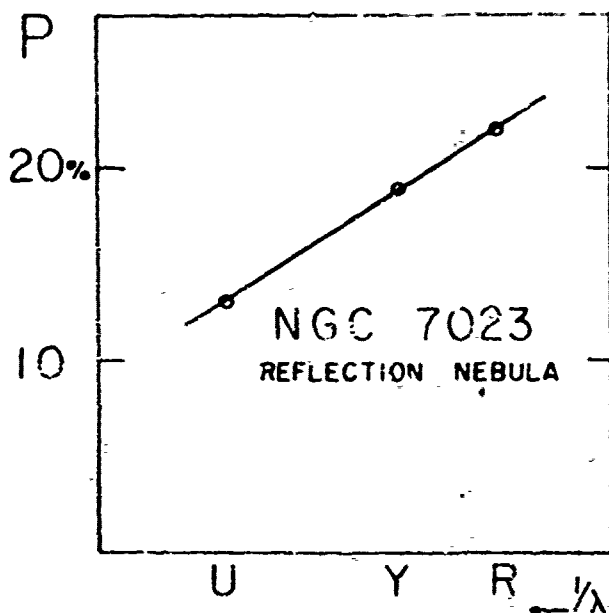


Figure 4. Polarization as a function of the reciprocal of the wave length. Tentative results for an area of 23" diameter in a reflection nebula. The effective wave lengths are at 3600 (U), 5400 (Y), and 7600 (R) Angstroms.

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