AN OBJECTIVE GRATING FOR VISUAL STELLAR PHOTOMETRY

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One of the most profitable branches of astronomy has been the study of double stars. Binary systems give the only direct means of determining the masses densities of stars; and the information which they have yielded has been of far-reaching importance in astro-physics. The astonishing frequency of occurrence of double stars reveals high cosmical significance, and the relations between relative magnitudes and spectral class are believed to have a promising bearing on the matter of stellar evolution.

Unfortunately, the observation of double stars is beset with serious difficulties due to the minuteness of the angles involved. Our present data regarding the magnitudes of binary system components is the weakest point, inasmuch as most values given are simple estimates. Photographic photometry is inaccurate because of the overlapping of images, the Eberhard effect, and the effect of bad "seeing." The author found it impossible to isolate the light of one star for measurement with a photoelectric cell.

A diffraction grating made on evenly spaced parallel wires is often used over a telescope objective as a photometric accessory. By this means, each stellar image is flanked with a series of spectral images whose intensities depend upon the ratio of the diameter of the wire,d, to the clear space,a. Referred to the free aperture of the telescope, the intensities of the central image and a diffraction image of n^{th} order are

$$\frac{a^2}{(a+d)^2} \text{ and } \left\{ \frac{\operatorname{Sin}\left\{\frac{a}{a+d} \cdot n\pi\right\}}{n\pi} \right\},$$

respectively.

The chief applications of the objective grating have been in photographic photometry: the determination of the effective wave-lengths of stars, the calibration of plates, and direct comparison of images. Hertzsprung and Kuiper have used such gratings visually, as means of estimating the magnitudes of double stars. They used a series of gratings so that the first order images of primary stars would be within a half a magnitude of the central image of secondary components.

The eye is a sensitive photometric device in favorable circumstances. It is at its best in matching intensities. It would seem, then, that visual photometry could be made more precise with the help of a grating whose ratio a/d could be varied continuously. In this way two stars could be compared by equalizing the central image of the fainter with a diffraction image of the brighter. Mental interpolation would be eliminated and the limit of accuracy would be set by the ability of the observer to match intensities. Such a grating has been made by the simple expedient of rotating the plane of the wires so that the clear spaces are foreshortened but the opaque spaces are unaffected. A grating with $a = 2d$ has been mounted on the 12″ reflecting telescope, hinged at one end. The inclination is read by a graduated arc, and a rotation of forty degrees changes the magnitude interval between central image and first order spectrum from 1.92 to 1.29 magnitudes. Auxiliary gratings could be made to extend the range to almost any desired value.

Rotation of the grating causes a change in the dispersion, due to the increased number of lines, and also in the total light loss, but neither of these influences the photometric action. It seems best, however, to use only the first order images as these are short enough to appear stellar, whereas higher orders begin to show color. It will be possible to investigate systematic errors, and also the mean accidental error of an observation, by means of a magnitiude sequence of 24 stars of similar color, which the author established in the Pleiades. Preliminary results indicate that this simple modification of the objective grating may be of service in visual photometry of variable stars as well as of binaries.