NOTES FROM OBSERVATORIES

LIMITING VISUAL MAGNITUDE

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In recent years the speed of astronomical spectrographs has been pushed to such a point that in some spectrographs the limiting magnitude may be set by the ability to locate visually and to guide on the object to be observed. As part of the program for the design and construction of spectrographs for the 200-inch telescope, it seemed desirable therefore to re-examine the problem of the limiting visual magnitude of a telescope and, in particular, to determine whether the limiting magnitude is dependent on such factors as the magnification.

The usual formula[1] for the limiting magnitude, m, visible in a telescope of aperture D inches is

$$m = 8.8 + 5 \log D. \qquad (1)$$

This corresponds to a limiting magnitude for the unaided eye of about 6. H. D. Curtis,[2] however, showed in 1901 that if the night-sky background were eliminated with an appropriate set of screens, it was possible to observe stars down to about the eighth magnitude with the unaided eye. Somewhat later, H. N. Russell[3] carried out experiments on artificial stars and was able to observe these stars against a completely black background when their brightness was equivalent to magnitude 8.5. In 1931, I. Langmuir and W. F. Westendorp,[4] as a result of extensive laboratory experiments, enunciated the law that the minimum intensity necessary for a point source to become visible on a luminous background varies as the square root of the brightness of the background. If we assume such a connection between minimum intensity and background brightness, it is evident that the limiting stellar magnitude should vary with the magnifica-

[1] G. Z. Dimitroff and J. G. Baker, *Telescopes and Accessories,* Blakiston and Co., p. 44, 1945.

[2] *Lick Obs. Bulletin,* **2,** 67, 1901.

[3] *Ap. J.,* **45,** 60, 1917.

[4] *Physics,* **1,** 273, 1931.

tion since the apparent brightness of the sky background varies as the square of the diameter of the exit pupil when this is smaller than the pupil of the eye.[5]

In the present re-examination of the problem, an investigation of the variation of limiting magnitude with the magnification was made, using telescopes of three apertures, ⅓ inch, the same as that of the eye when completely dark adapted, 6 inches, and 60 inches. All tests were made on clear moonless nights and the stars observed were located in a region of the sky well separated from the Milky Way and from interference with city lights. Great care was taken to keep the eyes completely dark adapted. A star was considered to be visible if it could be consistently seen by averted vision. The results of these observations are summarized in Figure 1, in which the observed limiting visual or photovisual magnitude minus 5 times log D, where D is the aperture of the telescope used, is plotted as a function of the log of the diameter of the exit pupil. The subtraction of 5 log D from the magnitudes reduces them to the magnitudes that would be observed with a telescope of 1-inch aperture. The slope of the solid straight line in Figure 1 corresponds to that predicted by the Langmuir-Westendorp square root law. The value of the limiting magnitude, m, as given by this line may be represented by the formula

$$m = 6.5 + 5 \log D - 2.5\, E \qquad (2)$$

in which E is the diameter of the exit pupil in inches. Since the magnification M is equal to D/E, this equation may also be written

$$m = 6.5 + 2.5 \log D + 2.5 \log M. \qquad (3)$$

For small telescopes and good "seeing," these formulae are valid for exit-pupil diameters from the maximum diameter of the dark-adapted eye (⅓ inch) down to about 0.03 inch. At this smaller diameter of the exit pupil the apparent brightness of the sky background has been reduced to about 1/100 of its value as seen with the naked eye. Presumably at this point the background intensity has become negligible and no further gain

[5] G. S. Monk, *Light, Principles and Experiments*, McGraw-Hill, p. 41 ff., 1937.

in limiting magnitude is obtained by pushing the background intensity to still lower values. With the 60-inch telescope no gain in limiting magnitude was observed for exit-pupil diameters below 0.07 inch. At the time of the tests with the 60-inch telescope, the "seeing" was about average, that is, 3 to 4 on the Mount Wilson scale, and with the magnification corresponding to the exit-pupil diameter of 0.07 inch, the star images were noticeably fuzzy. For still higher powers the images could no longer be considered as points and consequently it is not surprising that a departure from the Langmuir-Westendorp law occurred.

The points obtained with the 60-inch telescope are about 0.2 magnitude below those of the smaller telescopes, presumably because of the loss of light at the three reflections at aluminized mirrors. The smaller instruments were refractors with objectives having nonreflection coatings.

It is of interest to note from Figure 1 that the use of a

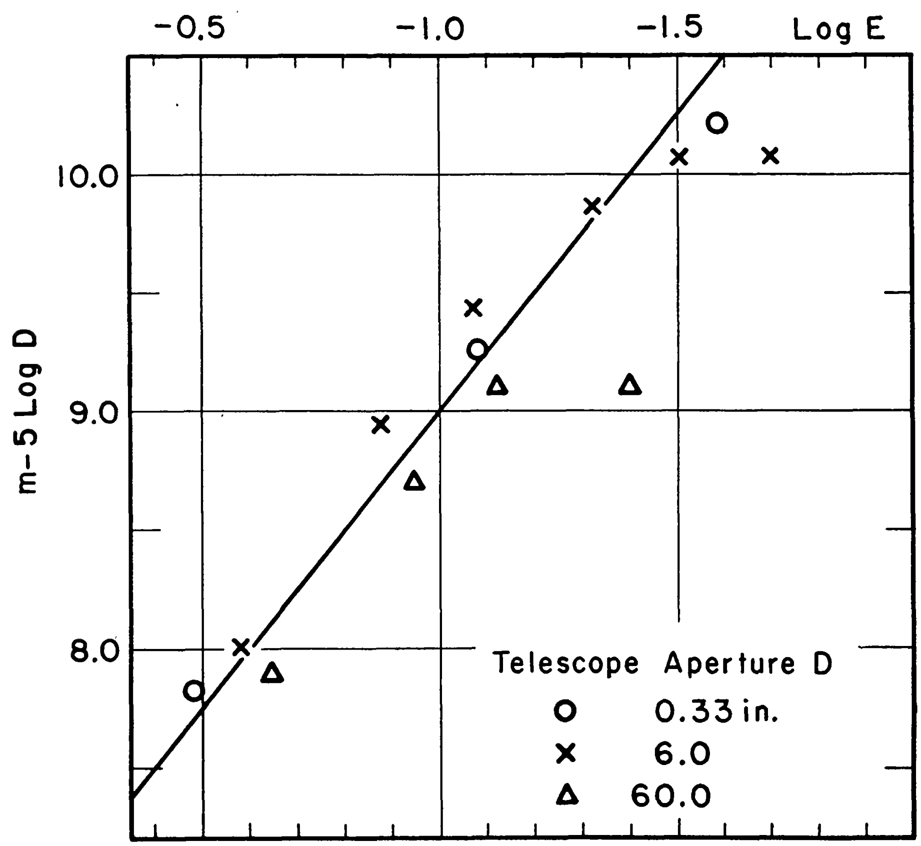

FIG. 1.—Limiting magnitude, *m,* as a function of diameter of exit pupil, *E.*

so-called "richest field telescope"[6] results in the loss of about one magnitude compared to that given by the usual formula (1). For the smaller telescopes, on the other hand, it is possible to observe stars a full magnitude fainter than that given by formula (1) if the optimum magnification of about 30 per inch of aperture is used.

THE HIGH-VELOCITY STAR HD 161817

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The A-type star HD 161817 (1900 R.A. $17^h\ 42^m\!.6$; Decl. $+25°\ 48'$; Mag. 6.9) was found to have the extremely high velocity -360 ± 6 km/sec by Albitzky at the Simeis Observatory.[1] Recent observations at Mount Wilson, listed in Table I, confirm this result.

TABLE I

Mount Wilson Spectrograms of HD 161817

Plate	Date	Dispersion at Hγ	Rad. V. km/sec	No. Lines	Neg. by	Meas. by
γ 28405	1947 Mar. 28	65 A/mm	−360.3	8	A. G. Mowbray	R. E. Wilson
γ 28441	Apr. 25	35	−367.6	20	A. G. Mowbray	R. E. Wilson
Ce 4681	May 5	10	−363.1	60	P. W. Merrill	C. G. Burwell

On the high-dispersion plate, velocities from various lines are in excellent agreement as shown by Table II.

TABLE II

Measurements of Plate Ce 4681

Lines	No.	Rad. V. km/sec
Hydrogen	8	−363.2
Neutral metals	23	−363.2
Ionized metals	27	−362.9
Ca II	2	−363.7

The proper motion $\mu_\alpha = -0\overset{''}{.}050 \pm 0\overset{''}{.}007$; $\mu_\delta = -0\overset{''}{.}064 \pm 0\overset{''}{.}005$ was determined by L. P. Svetlova,[2] who suggested

[6] *Amateur Telescope Making Advanced,* Munn and Co., p. 623, 1937.

[1] *Poulkovo Circular, No. 7,* 1933.

[2] *Astronomical Journal of the Soviet Union,* **23,** 147, 1946.