THE RATIO OF TOTAL TO SELECTIVE ABSORPTION FOR THE ORION NEBULA

Johnson and Borgman (1963) have recently derived a value of 7.4 ± 0.3 for the ratio, R, of total to selective absorption ($R = A_v/E_{B-V}$) for stars in the region of the Orion Nebula from *UBV* and infrared multicolor photometry. This tends to confirm the large value of 6 ± 1 derived by Sharpless (1952) from the variation of observed visual magnitude with color excess in the Orion association. Johnson and Borgman also find that stars show R progressively closer to 3 with increasing distance from the Nebula. However, Miss Underhill (1964) has questioned the conclusions they have drawn from their results, and Walker (1962) has already shown that the high value found by Sharpless can be explained by the combined effect of a moderate, but irregular, dependence of reddening on distance and the large extension of the association relative to its distance from the Sun.

Johnson and Borgman find that, for unit E_{B-V}, the stars of the Trapezium and θ^2 Orionis show much larger infrared color excesses than other stars in the Milky Way. Both they and Miss Underhill point out that this could be due to visually fainter, later-type stars being included in the photometry rather than to an anomalously high visual extinction. All the members of the Trapezium and the brighter star of θ^2 Orionis are, in any case, spectroscopic binaries (see Plaskett and Pearce [1930]). The sizes of the infrared color excesses, for unit E_{B-V}, are sensitive to the adopted values of E_{B-V}, particularly in Orion, where the values of E_{B-V} are small.

The $B - V$ colors measured by Sharpless (1952) are about 0.06^{m} redder than those measured by Johnson and Borgman for the stars of the Trapezium and θ^2 Orionis, but there is no systematic error between them for the other stars in Orion. If there is a tendency to measure colors systematically bluer for stars in the Nebula, because of the difficulties of compensating for the nebular background and close companions, this could account, at least in part, for apparently large infrared color excesses. As an illustration of the observational difficulties, the combined V magnitude observed by Johnson and Borgman for the Trapezium is 0.05^{m} brighter than the combination of the individual observed V magnitudes, 4.65 (assuming $V = 7.96$ for HD 37021). This is much greater than the quoted probable error in V of 0.013. Miss Underhill has also drawn attention to the high intrinsic scatter between the ratios of color indices for members of the Trapezium. She feels that this is due to anomalies in the stellar spectra rather than in the interstellar extinction.

From the MK-luminosity calibration of Johnson and Iriarte (1958), Johnson and Borgman find that the combined visual absolute magnitude of the Trapezium stars is -5.9; and, for a distance modulus of 8.1 to the Nebula, this implies a visual extinction, A_v, of 2.4, and hence, since $E_{B-V} = 0.33$, this gives $R = 7.3$. This argument is not quite consistent, however, with a later statement that if $R = 7.4$ for the Nebula, then its distance modulus becomes 7.1; for this would imply that $R = 10.3$ on the basis of the combined MK absolute magnitudes and B, V photometry.

The distance of the Orion association can be derived almost independently of R since the fainter members used in the procedure of main-sequence fitting show only small values of E_{B-V}. Sharpless (1962) finds $\bar{E}_{B-V} = 0.06^{\mathrm{m}}$ for the majority of stars in the Sword region of Orion. Johnson and Iriarte (1958), using Sharpless' (1952) data, derived a distance modulus of 8.1 for the association by the technique of main-sequence fitting in the color-magnitude diagram. Petrie (1964) has recently recalibrated the $W_{\mathrm{H}\gamma}$–absolute-magnitude relation. From this calibration he has derived the same distances as Johnson for a number of clusters and associations including the Orion association. The latter is also based on stars with a mean $E_{B-V} = 0.06^{\mathrm{m}}$.

The values of $W_{H\gamma}$ donot support the high combined MK absolute visual magnitude for the Trapezium stars. Table 1 lists separately the four stars of the Trapezium (HD 37020–3), and θ^2 Orionis (HD 37041 and 37042).

The V magnitudes are taken from Sharpless (1962) and the E_{B-V} are derived from the $B - V$ values he quotes, the spectral types given by Petrie, and the intrinsic colors given by Johnson (1958). The M_{sp} were derived from the $W_{H\gamma}$-M_v relation and $W_{H\gamma}$ measures determined by Petrie. R has been derived, assuming a distance modulus of 8.1, from the relation $R = (V - M_{sp} - 8.1)/E_{B-V}$.

The mean R for all the stars is 3.6 ± 1.3 (m.e.). HD 37020 shows a very large positive residual. If it is left out the mean R is 2.9 ± .7 (m.e.). All but HD 37042 are considered to be single-line spectroscopic binaries. R', in the last column, has been calculated on the

TABLE 1

THE PHOTOMETRIC DATA FOR THE TRAPEZIUM STARS AND HD 37041 AND 37042

Star	V	E_{B-V}	M_{sp}	R	R'
HD 37020	6 75	0 30	−3 3	6 7	7 8
37021	7 96	44	−2 0	4 3	5 0
37022	5 14	38	−4 2	3 2	3 9
37023	6 70	41	−2 5	2 7	3 4
37041	5 07	25	−3 7	2 8	4 0
37042	6 38	0 25	−2 1	1 6	1 6

assumption that the secondary components contribute 0.3^m to the observed visual magnitudes. The mean R' for all six stars is 4.3 ± 1.2 (m.e.) and 3.6 ± .9 (m.e.) when HD 37020 is left out. It should be stressed that the above values of R and R' are based on the photometry by Sharpless. Clearly the values would be larger if the bluer colors observed by Johnson and Borgman were used.

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REFERENCES

Johnson, H. L. 1958, *Lowell Obs. Bull.*, No. 90
Johnson, H. L., and Borgman, J. 1963, *B.A.N.*, **17**, 115.
Johnson, H. L., and Iriarte, B. 1958, *Lowell Obs. Bull.*, No 91.
Petrie, R. M. 1964 (in press).
Plaskett, J. S., and Pearce, J. A. 1930, *Pub. Dom. Ap. Obs.*, **5**, 1.
Sharpless, S. L. 1952, *Ap. J.*, **116**, 251.
———. 1962, *ibid.*, **136**, 767.
Underhill, A. B. 1964, *Observatory*, **84**, 36.
Walker, G. A. H. 1962, *Observatory*, **82**, 52.