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REAL AND APPARENT RADIAL VELOCITIES.

By A. V. Douglas.

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REAL AND APPARENT RADIAL VELOCITIES.

BY

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(*Communicated by Professor Eddington, F.R.S.*)

The complete Doppler formula obtained by Silberstein * from de Sitter's spacetime theory, into which no limitation whatever is introduced, the observing station and star being treated as two free particles and the equations integrated in their full generality, is as follows :—

$$D = \gamma \left[1 \pm \sqrt{1 - \frac{\cos^2 \frac{r}{R}}{\gamma^2}} \right] - 1$$

where D = complete spectral displacement.

$\gamma = \dfrac{1}{\sqrt{1 - \dfrac{v_0^2}{c^2}}}$ always slightly greater than 1, not determinable theoretically, but only by observation of Nature.

r = distance to star from observer.

R = curvature invariant of spacetime.

This formula for the spectral shift resolves itself into two parts—(1) a term depending upon an individual characteristic of any star, v_0, its actual radial velocity at its nearest approach to the observer whether that occurred in the past or will occur in the future, (2) a term depending upon the ratio $\frac{r}{R}$ and thus due to the four dimensional nature of elliptical spacetime.

* *Nature*, 1924 March 8, p. 350.

Although these two terms are inseparably amalgamated, yet for stars near to the observer it is evident that the first term dominates the result, while for very remote celestial objects the second term completely outweighs the first.

Assuming Silberstein's value of R as 4×10^7 parsecs and r to lie between 100 and 1000 parsecs, then term (2) lies between 0·7 and 7 km. per sec., and may thus be not merely comparable to but even equal to or greater than the true v_0-velocity.

In the light of the above it seems advisable to reconsider the work which has been done with regard to the progression of velocity with absolute magnitude.

W. S. Adams * showed that for K and M giants the radial velocity and its progression with absolute magnitude were greater than the tangential velocity and its progression; while for the giants of all types (F to M) taken together, the reverse was the case, the radial velocity and its progression being the smaller.

Eddington † showed for the G_8 to K_2 giants, when due allowance was made for the systematic effect arising from accidental errors in the spectroscopic determinations of absolute magnitude and parallax, and when using the value $\pm 0^m{\cdot}3$ for the probable error of the absolute magnitudes, that the progression derived from the proper motion data became comparable with, though not quite as great as, that obtained by Adams for radial velocities. If, however, the value $\pm 0^m{\cdot}4$, given by Adams ‡ as the probable error, was used, the resulting progression for the tangential velocity was more than doubled.

The question which Silberstein's work suggests is that the progression derived from radial velocities is not a true progression. It is influenced by the unduly high velocities of the remote stars, due solely to their distances, which stars in the catalogue are for the most part of high luminosity. Since the true v_0-velocities of those stars, which are both very bright and very remote, should be less than the values assigned to them, it is evident that the progression for true radial velocities should be greater than that given.

The list of spectroscopic parallaxes § used in both the above-mentioned investigations is made up, to the extent of perhaps 20 per cent. of its total, of stars distant between 100 and 1000 parsecs, and as has been pointed out this distance may cause the r/R shift to equal or outweigh the shift due to true velocity. Thus 20 per cent. of the stars involved in the investigation—and these belonging chiefly to the most luminous groups—would have their velocities reduced to varying extents, and it seems probable that this would produce a considerable change in the factor b in Adams' formula $\log v = a + bm$.

It would be interesting if this brought b up to such a value that it represented a progression comparable with that given by Eddington's formula $v = a + bm$ for tangential velocity, when the probable error of absolute magnitudes is taken nearer the value $\pm 0^m{\cdot}4$ given by Adams.

* Adams, Strömberg, and Joy, *Ap. J.*, **54**, 1921 (Table III., p. 9).
† Eddington and Douglas, *M.N. R.A.S.*, 1923 January.
‡ Adams, Joy, Strömberg, and Burwell, *Ap. J.*, **53**, p. 15, 1921.
§ *Ap. J.*, **53**, 1921.

But it was pointed out by Eddington that there is little hope of determining this probable error precisely, and therefore no reliable progression can be obtained from proper motion data with which to compare the progression for radial velocity in an attempt to work backward to an average value of v_0. If a large number of values of v_0 were calculated, it seems as though they alone would provide the material from which the progression of velocity with absolute magnitude might be determined.

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