STELLAR OUTFLOW: RELATIVE MOTIONS OF NEBULAE AND Of STARS

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On the basis of arguments presented by Roberts (1972) and of Shu et al. (1972), Minn and Greenberg (1973) argued that the velocity differences between newly formed hot stars and the surrounding interstellar medium are sufficiently different so that typical H II regions should consist of material which is continually being replaced by the ambient medium and which should therefore possess the velocity of the medium rather than that of the star. Obviously, the critical test of this hypothesis will be a comparison of nebular velocities with the velocities of the exciting stars.

The extensive Fabry-Perot observations of Georgelin and Georgelin (1970) and the radio measures of the hydrogen alpha recombination lines have provided a wealth of data on radial velocities of emission regions. The recent paper by Conti et al. (1977) contains a list of radial velocities of O and Of stars having known orbits or identified as single stars. Cruz-Gonzalez et al. (1974) have identified the H II regions in which the O and Of stars appear on the Palomar Schmidt prints; those stars too far south for such identification have been tentatively identified with emission nebulae by using the Rodgers et al. Atlas of the Southern Milky Way (1960).

Conti's list includes 87 O stars and 16 Of stars with well-determined radial velocities. Of this group, 42 O stars and 11 Of stars appear to be associated with H II regions of measured radial velocities. A comparison of the stellar and nebular velocities is given in Figure 1. A least squares solution fits a straight line with a slope of nearly 1 to the O stars, with a zero-point shift of +3.5 km/sec. Data for the Of stars have much greater scatter and suggest a zero-point shift of -28 km/sec.

All velocities were next reduced to the local standard of rest using the standard solar motion traditionally used by radio astronomers for the 21-cm measures, i.e., 20.0 km/sec toward 18^h right ascension and +30° declination, and then corrected for circular galactic rotation by using the distance modulus for the stars given by Cruz-Gonzalez

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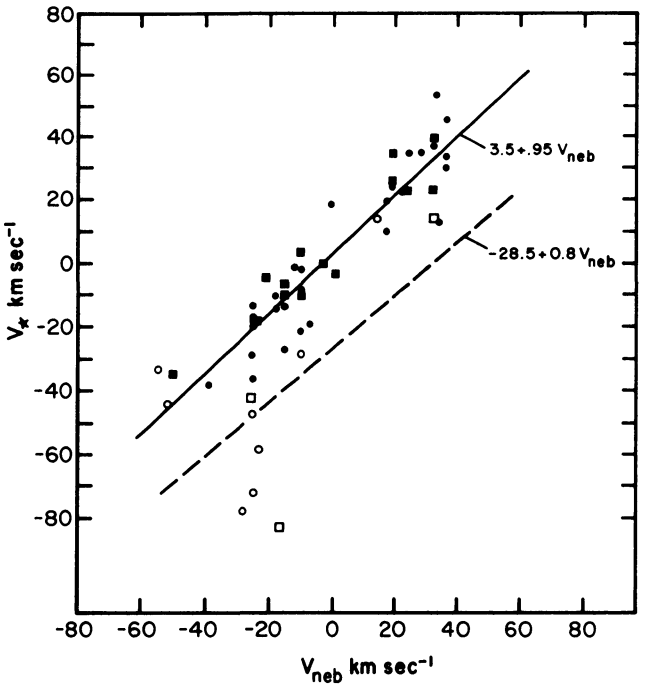

Figure 1. The filled squares and circles represent O stars of known orbital or single-star velocity, respectively; the open squares and circles refer to the Of stars in the same manner.

et al. and the galactic model of Burton and Gordon (1978) derived from CO data. The following table summarizes the results.

Comparison of Radial Component of Peculiar Velocity

	No.	V_{pec} (km/sec) *	Neb	σ (km/sec) *	Neb
Average by Nebulae					
O-stars	22	+ 5	+ 1	10	6
Of-stars	9	-24	- 4	24	16
Of-stars (alt)	7	-27	+ 2	23	9

The velocities were found by averaging nebulae, the stellar velocities for which may be the mean of several stars associated with a given nebula.

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Two of the Of nebulosities appear to be anomalous. One is NGC 6164 associated with HD 148937, for which Pismis (1974) has obtained detailed Fabry-Perot interferograms which clearly show that the large negative velocity obtained by Georgelin and Georgelin represents an expansion velocity rather than a spacial kinematic velocity. The other object is NGC 7635 and may exhibit similar expansion-type velocities. Averages of the velocities after eliminating these two nebulae are shown on the Of star (Alt) line of the table.

The probable errors of all means are about 1-3 km/sec and therefore it is concluded that all groups of peculiar velocities except those of the Of stars average to about zero. The Of stars exhibit the "K-term" found by Conti (from the same data, of course) of about -25 km/sec. The fact that the nebular velocities for both O and Of stars appear to have the same velocity distribution suggests that it is the Of velocities which are anomalous.

It seems reasonable to conclude that for this sample there is no large velocity difference between the exciting stars and the associated nebulosities produced by galactic streaming motions. The large negative K term of the Of stars is best interpreted as Conti has proposed, i.e., an effect produced by the absorption-line producing layer of the star.

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