

BINARY FREQUENCY AMONG THE O-TYPE STARS

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A great deal of work has been done on the theory of mass loss and evolution in close binaries, and numerous individual systems have been discussed in this connection, but the general question of the binary frequency of O-stars, and in particular, the initial binary mass ratio frequency or distribution of secondary masses, has not been completely answered. In general, we know that about half of all O-type stars are binaries; the most recent determination by Conti, Leep and Lorre (1977) found 58% of their sample to be certain or probable binaries. However, many of these stars were judged to be variable on the basis of only a few spectra from different sources, and therefore require further study. Another point to be examined concerns the binaries with available orbits: two thirds of these are double line systems. Figure 1 shows a plot of the semi-amplitude versus orbital period for all known systems, along with some theoretical curves for different mass ratios. Not only is the lack of single line systems obvious, but low amplitude systems are almost completely missing. This would appear to be only an observational selection effect, although it is to be noted that low amplitude double line Wolf-Rayet systems have been detected. If the effect is real, it implies that O-type binaries with mass ratios (m_1/m_2) greater than about three do not exist.

This type of effect is not observed among the B-type stars. Studies by Abt and Levy (1978), Wolff (1978) and Blaauw and Van Albada (1974) show no lack of single line, low amplitude systems, and even allowing for a smearing effect in $\sin i$, there are certainly B-type systems with mass ratios greater than three. When a preliminary study of some of the stars listed as variable by Conti, Leep and Lorre failed to detect any low amplitude, short period binaries (Bohannon and Garmany 1978) we began a systematic search of the O-stars.

To eliminate the observational selection effects of Fig. 1, we have examined all the O-stars brighter than 7th magnitude and north of -50° , a sample of 76 stars. In the cases of known binaries with published orbits we have made no further observations, but any star judged variable by Conti, Leep and Lorre has been reobserved by Conti and

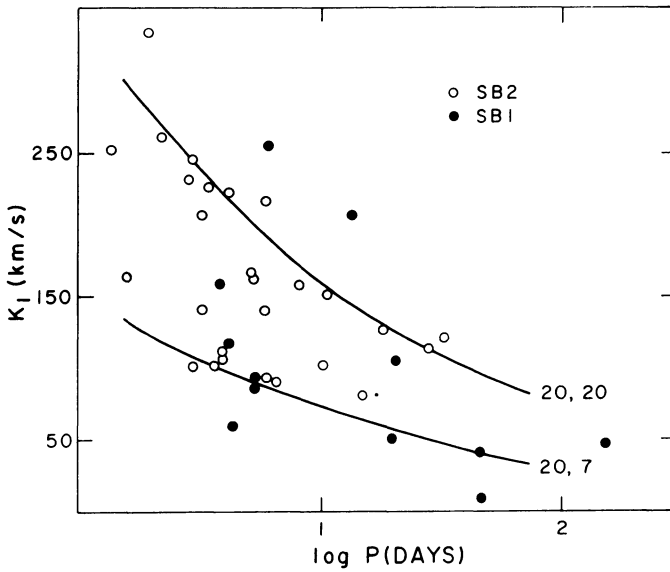


Figure 1. Semi-amplitude versus orbital period for all O-type binaries.

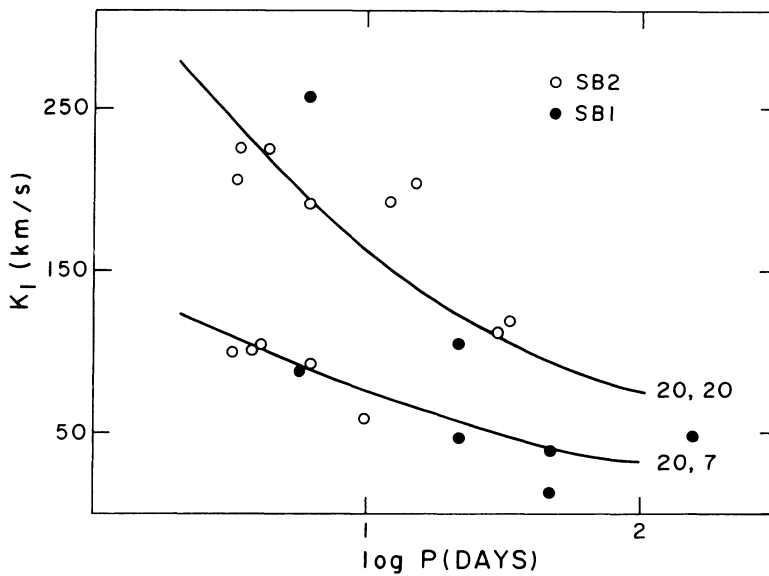


Figure 2. Semi-amplitude versus orbital period for the O-type binaries corrected for observational selection effects.

members of his group using the coude spectrograph at Kitt Peak National Observatory. Morrison and Massey will report on the new binaries. Despite the use of analysis of variance tests (Tryon and Garmany, in preparation) to measure radial velocity variations, we have not found any short period, low amplitude binaries although we expect to detect semi-amplitudes as low as 15 km/sec. Preliminary results are shown below in comparison with early B-stars (Blaauw and Van Albada 1974) and middle B-stars (Abt and Levy 1978):

PRELIMINARY BINARY FREQUENCY OF O AND B STARS

	04-09	09-B3	B2-B5
Single	53%	50%	51%
SB2	25%	15%	11%
SB1	11%	21%	25%
Triple	11%	14%	13%

The percentage of single stars does not vary, but the proportion of double line to single line binaries is much higher among the O-stars. Figure 2 shows the semi-amplitude versus orbital period for all the O-binaries in our sample, and even with no correction for $\sin i$, there seem to be no systems with mass ratios greater than about three.

There are several possible physical mechanisms which might be responsible for this effect. The O-stars may be unable to form stable systems if the primary star reaches the main sequence much in advance of the secondary, and thus no systems would exist with large mass ratios. Another interesting possibility which would explain the mass ratios of the most massive O-stars concerns the evolutionary consequences of moderate mass loss. Recent calculations by Vanbeveren, De Greve, van Dessel and de Loore (1978) show that with the assumption of main sequence mass loss, the mass ratios of O-type binaries will tend towards one, and they predict an overabundance of mass ratios smaller than 1.4 for unevolved massive close binaries.

This work was supported in part by National Science Foundation grant AST76-20842 to the University of Colorado.

REFERENCES

- Abt, H.A. and Levy, S.G.: 1978, *Astrophys. J. Suppl.* 36, p. 241.
 Blaauw, A. and Van Albada, T.: 1974, unpublished.
 Bohannon, B. and Garmany, C.D.: 1978, *Astrophys. J.* 223, p. 908.
 Conti, P.S., Leep, E.M. and Lorre, J.J.: 1977, *Astrophys. J.* 214, p. 759.
 Vanbeveren, D., De Greve, J.P., van Dessel, E.L. and de Loore, C.: 1978, (preprint).
 Wolff, S.C.: 1978, *Astrophys. J.* 222, p. 556.

DISCUSSION FOLLOWING GARMANY

Underhill: Two selection effects may be present in the published information on O-type binaries: (1) Single-spectrum O-type stars with variable radial velocity were rarely observed intensively because the probable yield of information did not justify the observing time which would be required to find an orbit with the available equipment, and (2) the strong absorption lines which could be measured on the low-dispersion prismatic spectra which were available were chiefly those of H, He I and He II, all of which are broadened by Stark effect. The net effect is that two spectra can be separated only if K is large; most cases of moderate or small K would be reported as a broad-lined, constant-velocity star. The plate files at the Dominion Astrophysical Observatory may contain much useful information for your project. The early prismatic spectra are wide and they are obtained on a fine-grained, blue-sensitive emulsion.

Garmany: Yes, we have considered these selection effects. Our new data, however, are all from 18 Å/mm Coudé plates taken at KPNO by Conti and others in his group. We have examined both suspicious velocity variables and a certain number of stars reported as constant in velocity, and have performed an analysis of variance test to handle both line to line and plate to plate variations (details of method in Bohannon and Garmany, Ap.J. 1978, 223, 908). We believe that we can detect variability if the semi-amplitude is greater than 15 km/s. The case of unresolved double lines is not completely satisfactory, but this does not change our results concerning binaries with mass ratios greater than about three.

Bohannon: No matter what the observational selection effects are, the mass ratio of an O-type binary system is physically defined by the fragmentation which results from too much angular momentum and by the radiation pressure of the more massive star as it achieves main sequence luminosity. The latter process should be readily evaluated by existing radiation driven mass loss theories.