THE ORIGIN OF WR 140

J.P. DE GREVE
Astrophysical Institute, VUB
Pleinlaan 2, B-1050 Brussels, Belgium.

The formation of the eccentric, long period binary WR 140 (HD 193793, WC7 + O4-5V, e= 0.8, P = 7.9 yr), in terms of an eccentricity modulated late case B of mass transfer, is investigated. Using only stellar wind models, it is impossible to obtain a combination of a spectral type O4-5 together with a WC star.

Assuming that the initial stars have masses 40 and 25 M_O and adopting the present period and radius, the Roche radius of the primary at periastron and apastron is respectively 242 R_O and 2400 R_O. On the other hand, the primary will ascend the giant branch around log T_{eff} = 3.6, log L/L_O = 5.6, implying a radius of 1330 R_O and more. The dynamical timescale of the convective envelope is of the order of periastron passage, i.e. $\sim$ 1 yr. This results in mass transfer, periodically modulated by the large eccentricity.

Fixing the observed mass ratio at 0.22 (Moffat et al., 1987, Williams et al., 1990) and taking the present mass of the O-type star according to its spectral type (40 M_O), we can calculate the initial masses and period, using the models of Maeder and Meynet (1987) and adopting a spherical symmetric stellar wind and conservative mass transfer. The result is a massive system with P_i = 3.2 yr and masses 47 M_O and 39 M_O (the eccentricity was assumed to remain constant).

Several processes might influence the eccentricity : stellar wind (Hadjidimetriou, 1976), mass transfer (Hut and Paczynski, 1984), tidal evolution (Alexander, 1973, Hut, 1981, 1982). We investigated the influence of isotropic mass loss following an Eddington-Jeans law $M = - d M^n$. Only in the case $n > 3$ the average eccentricity will decrease. Using various formalisms published in the literature, we found that WR 140 probably had an eccentricity larger than the present one. Mass transfer cannot modify the average value of the eccentricity, though it causes secular changes to occur. Tidal interaction, treated with the weak friction appoximation (Zahn, 1977), affects the eccentricity on a timescale much larger than the evolutionary timescale of the system.

References.

Alexander, M. E. : 1973, Astrophys. Space Sci. 23, 459.
Hut, P. : 1981, Astron. Astrophys. 99, 126.
Hut, P. : 1982, Astron. Astrophys. 110, 37.
Hut, P., Paczynski, B. : 1984, Astrophys. J. 284, 675.
Maeder, M., Meynet, G. : 1987, Astron. Astrophys. 182, 243.
Maeder, M., Meynet, G. : 1988, Astron. Astrophys. Suppl. Ser. 76, 411
Moffat, A.F., Lamontagne, R., Williams, P.M., Horn, J., Seggewiss, W. : 1987, Astrophys. J. 312, 807.
Williams, P.M., van der Hucht, K.A., Pollock, A.M.T., Florkowski, D.R., van der Woerd, H., Wamsteker, W.M. : 1990, M.N.R.A.S. 243, 662.
Zahn, J.P. : 1977, Astron. Astrophys. 57, 383.

K. A. van der Hucht and B. Hidayat (eds.),
Wolf-Rayet Stars and Interrelations with Other Massive Stars in Galaxies, 252.