THE EFFECT OF ORBITAL ECCENTRICITY ON POLARIMETRIC BINARY DIAGNOSTICS

C. Aspin, J.C. Brown, J.F.L. Simmons
Dept. of Astronomy, University of Glasgow, U.K.

ABSTRACT. The polarimetric variation from a binary system with an eccentric orbit, thus non-corotating, are calculated and the effect on determining the system parameters is discussed, relative to the circular case.

We relax the assumption of corotation implicit in the canonical model of polarimetric binaries (Brown et al 1978) by considering a localized scattering region in an orbit of eccentricity e about a single light source. This scattering 'blob' has N electrons and can be considered in physical terms as similar to a small accretion disk around a compact star i.e. neutron star or black hole.

The introduction of the eccentricity results in the model predicting variations in the Stokes Parameters Q and U with binary phase of harmonics, in addition to the basic second harmonics which characterise circular orbits when the scatterers are symmetric about the orbital plane. The variation of the source to scatterer distance can be treated purely geometrically in terms of binary phase and the harmonic phase dependence of Q and U can be found exactly so yielding the form of the locus described in the Q,U plane, once per orbital period. Since we take our Q,U measurements in time rather than phase we have re-expressed the eccentric orbit model's predictions in this form by a solution of Kepler's equation to order e which will suffice for all practical cases.

It is found that (Q,U) time harmonics up to and including third are present in this approximation, the first and third harmonic coefficients being respectively of order e and 3e relative to the dominant second harmonics. The resulting harmonic coefficients are:

$$\begin{array}{ll}
p_1 = \tau_* e \cos \Lambda p(1+\cos^2 i) & u_1 = 2\tau_* e \sin \Lambda p \cos i \\
q_1 = -\tau_* e \sin \Lambda p(1+\cos^2 i) & v_1 = 2\tau_* e \cos \Lambda p \cos i \\
p_2 = -\tau_* (1+\cos^2 i) & u_2 = -8\tau_* e \sin \Lambda p \cos i \\
q_2 = 4\tau_* e \sin \Lambda p(1+\cos^2 i) & v_2 = -2\tau_* \cos i \\
p_3 = -3\tau_* e \cos \Lambda p(1+\cos^2 i) & u_3 = 6\tau_* e \sin \Lambda p \cos i \\
q_3 = -3\tau_* e \sin \Lambda p(1+\cos^2 i) & v_3 = -6\tau_* e \cos \Lambda p \cos i
\end{array} \qquad (1)$$

M. J. Plavec, D. M. Popper and R. K. Ulrich (eds.), Close Binary Stars: Observations and Interpretation, 71–72.

https://doi.org/10.1017/S0074180900064627 Published online by Cambridge University Press

where e = eccentricity; Λ_p = longitude of periastron and τ_* = weighted optical depth of the scatterer.

These coefficients are therefore functions of e, i, Λ_p, τ_* and Θ the orientation of the binary axis relative to the (Q,U) lab frame. It is shown how, given accurate data, one can solve for these variables in terms of the harmonic coefficients, together with several consistency checks on the results.

The possibility is then discussed that a wrong determination of i (or any other parameter) could be made if a canonical model with circular orbit, but asymmetric envelope geometry, were applied to diagnosing a truly eccentric orbit situation. It is shown that the model predictions are in fact mutually exclusive and so the correct model centre found if the data are accurate enough (eg. the canonical model predicts no third harmonics).

At present we are extending this analytic treatment to the more realistic case of noisy data by employing the optimization technique of Simmons et al (1979). Our aim is to obtain the best fit eccentric orbit parameters and their associated confidence intervals for interesting systems such as Cygnus X-1 using data of (eg. Kemp et al, 1979).

We acknowledge receipt of an S.R.C. travel grant to enable C.A. and J.F.L.S. to attend the Symposium.

References.

Brown, J.C., McLean, I.S. and Emslie, A.G.: 1978, Astron. Astrophys. 68, 415.

Kemp, J.C., Barbour, M.S., Parker, T.E. and Herman, L.C.: 1979, Ap.J. Letters, 228, L23.

DISCUSSION FOLLOWING McLEAN and ASPIN et al.

Massey: Have you combined your ephemeris with Moffat's proposed "velocity curve", or is the period too uncertain? Did you derive the period independently?

McLean: The zero phase shown in the Figure is based on Moffat's ephemeris (WR star in front). Since the polarimetry was obtained a year or so after the spectroscopy, and the period still is a little uncertain, then there is an uncertainty of about 0.05 in the location of zero phase. We do derive the period independently but only to an accuracy of about 0.01 day.