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# Mira kinematics from *Hipparcos* data: a Galactic bar to beyond the Solar circle

Michael W. Feast[1★] and Patricia A. Whitelock[2★]

[1] *Astronomy Department, University of Cape Town, Rondebosch 7701, South Africa*

[2] *South African Astronomical Observatory, PO Box 9, Observatory 7935, South Africa*

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**ABSTRACT**

The space motions of Mira variables are derived from radial velocities, *Hipparcos* proper motions and a period–luminosity relation. The previously known dependence of Mira kinematics on the period of pulsation is confirmed and refined. In addition, it is found that Miras with periods in the range 145–200 d in the general Solar neighbourhood have a net radial outward motion from the Galactic Centre of $75 \pm 18\,\mathrm{km\,s^{-1}}$. This, together with a lag behind the circular velocity of Galactic rotation of $98 \pm 19\,\mathrm{km\,s^{-1}}$, is interpreted as evidence for an elongation of their orbits, with their major axes aligned at an angle of $\sim 17°$ with the Sun–Galactic Centre line, towards positive Galactic longitudes. This concentration seems to be a continuation to the Solar circle and beyond of the bar-like structure of the Galactic bulge, with the orbits of some local Miras probably penetrating into the bulge. These conclusions are not sensitive to the distance scale adopted. A further analysis is given of the short-period (SP) red group of Miras discussed in companion papers in this series. In Appendix A the mean radial velocities and other data for 842 oxygen-rich Mira-like variables are tabulated. These velocities were derived from published optical and radio observations.

**Key words:** catalogues – stars: variables: other – Galaxy: kinematics and dynamics – Galaxy: structure.

## 1 INTRODUCTION

This is the last paper in a group of three (although the first of the group to appear in print) which discuss the Mira-like[1] variables contained in the *Hipparcos* catalogue (Perryman et al. 1997). In Whitelock, Marang & Feast (2000, hereafter Paper I) infrared (*JHKL*) and other photometry were discussed and various conclusions reached, including the identification of two distinct groups of oxygen-rich short-period variables: our Short-Period blue (SP-blue) and Short-Period red (SP-red) stars (see also Hron 1991). The SP-blue stars, on the basis of their colours and their kinematics, were identified as an extension of the main Mira sequence to short periods. These stars appear to be the field equivalent of the Mira variables found in globular clusters. On the other hand, it was concluded that the SP-red variables were on evolutionary tracks of which longer-period stars of the main Mira sequence were the end-points, and/or that they were pulsating in a higher mode than the longer-period Miras (see also Section 6 below).

Whitelock & Feast (2000, hereafter Paper II) calibrated the Mira infrared period–luminosity (PL) relation using data from Paper I and the *Hipparcos* parallaxes. Evidence for a luminosity difference between the SP-blue and SP-red stars of a given period was found, consistent with the conclusions of Paper I. In Papers I and II a discussion was also given of carbon-rich Miras.

The present paper, which is restricted to the discussion of oxygen-rich stars, investigates the Galactic kinematics of Mira-like variables on the basis of *Hipparcos* proper motions and published radial velocities. Previous work has generally either discussed the Galactic kinematics of Miras from radial velocities alone (e.g. Feast 1963; Smak & Preston 1965; Feast, Woolley & Yilmaz 1972) or combined radial velocities with proper motions in a discussion of statistical and secular parallaxes (e.g. Clayton & Feast 1969; Robertson & Feast 1981). The radial velocity discussions established a correlation of asymmetric drift and velocity dispersion with period. The shortest-period Miras (periods less than ∼145 d) were anomalous, and it was at one time suggested (Feast 1963) that they were overtone pulsators (the bulk of the Miras pulsating in the fundamental). However, as discussed in Paper II, it now seems likely that most Miras are pulsating in the first overtone. The nature of the short-period stars is clarified in Papers I and II and in Section 6 of this paper. The present paper gives improved mean motions and velocity dispersions for Miras as a function of period, and gives further evidence for the distinction between SP-blue and SP-red variables. In addition to asymmetric drift, it is found that Miras, particularly those in the

★ E-mail: mwf@artemisia.ast.uct.ac.za (MWF); paw@saao.ac.za (PAW)

[1] The definition of 'Mira-like' is given in Paper I.

**Table 1.** Individual space velocities (km $s^{-1}$). (a) SP-reds omitted.

| Name | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ | $\sigma_u$ | $\sigma_v$ | $\sigma_w$ | $\sigma_{V_R}$ | $\sigma_{V_\theta}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *Group 1* | | | | | | | | | | |
| CI Vel | −38.5 | −32.8 | 22.1 | −54.0 | 194.6 | 37.4 | 13.1 | 41.2 | 28.6 | 8.8 |
| T Gru | 207.1 | −147.9 | 108.3 | −205.9 | 86.0 | 16.3 | 10.9 | 10.8 | 16.2 | 8.8 |
| *Group 2* | | | | | | | | | | |
| SW Scl | −57.5 | 5.4 | −38.4 | 57.5 | 236.4 | 5.7 | 1.0 | 5.0 | 5.7 | 1.0 |
| R Ari | −162.8 | −126.7 | −80.3 | 170.2 | 91.8 | 8.0 | 8.2 | 8.6 | 8.1 | 7.8 |
| X Cet | −76.8 | −119.3 | 16.4 | 76.1 | 112.2 | 41.3 | 39.5 | 40.0 | 41.3 | 26.7 |
| X Aur | 29.0 | −18.8 | 29.3 | −22.7 | 212.9 | 5.0 | 5.2 | 6.4 | 5.0 | 4.7 |
| RV Pup | −6.5 | −65.8 | −44.6 | −15.8 | 164.5 | 6.5 | 5.2 | 6.0 | 6.6 | 5.5 |
| S Car | −200.8 | −338.1 | 6.2 | 206.8 | −95.1 | 2.1 | 4.8 | 1.5 | 2.3 | 4.9 |
| RR Boo | −38.1 | −82.4 | 9.2 | 60.6 | 140.9 | 22.7 | 36.0 | 25.4 | 28.3 | 48.0 |
| RZ Sco | −165.4 | −120.4 | −94.8 | 161.2 | 116.6 | 11.3 | 24.5 | 25.1 | 11.1 | 19.1 |
| T Her | −81.9 | −76.8 | −18.5 | 97.0 | 145.2 | 4.4 | 4.6 | 4.1 | 4.5 | 4.7 |
| W Lyr | −29.3 | −131.3 | −97.0 | 40.6 | 95.7 | 4.7 | 4.8 | 4.5 | 4.8 | 4.8 |
| RW Sgr | −14.9 | −64.2 | 36.3 | 21.9 | 166.0 | 5.2 | 5.0 | 6.3 | 5.2 | 5.2 |
| RT Cyg | −54.7 | −113.5 | 62.1 | 69.9 | 109.2 | 4.7 | 5.0 | 4.3 | 4.7 | 5.0 |
| R Pic | −223.7 | −219.6 | 18.2 | 221.5 | 33.6 | 2.7 | 4.3 | 4.1 | 2.6 | 4.2 |
| X Mon | −66.8 | −139.4 | −37.5 | 61.2 | 95.5 | 4.2 | 4.1 | 3.6 | 4.1 | 3.9 |
| X Oct | −36.3 | −18.8 | 22.2 | 24.0 | 213.9 | 3.0 | 4.2 | 3.0 | 3.1 | 4.3 |
| BZ Vir | −38.4 | −4.6 | 25.6 | −6.2 | 229.5 | 26.2 | 24.3 | 18.9 | 25.7 | 15.3 |
| V CVn | 3.3 | −47.1 | 17.8 | −0.2 | 183.9 | 0.8 | 2.0 | 4.7 | 0.8 | 2.0 |
| S Aql | −85.0 | −65.9 | −32.0 | 111.0 | 148.9 | 12.7 | 8.4 | 13.0 | 11.5 | 7.6 |
| XZ Her | 376.0 | −254.6 | −113.9 | −291.2 | 239.0 | 125.6 | 130.9 | 179.7 | 55.6 | 55.8 |
| *Group 3* | | | | | | | | | | |
| U Cet | 8.1 | −47.5 | 47.4 | −9.5 | 183.4 | 11.4 | 6.0 | 7.4 | 11.3 | 5.0 |
| T Hor | −40.0 | −103.9 | 29.6 | 29.0 | 130.0 | 4.4 | 7.1 | 6.4 | 4.4 | 7.7 |
| T Pic | 48.1 | −114.7 | 86.2 | −66.5 | 106.8 | 12.9 | 9.5 | 11.7 | 13.0 | 9.7 |
| T Col | −55.1 | −59.2 | 53.7 | 45.1 | 174.6 | 3.4 | 3.9 | 3.4 | 3.3 | 3.8 |
| S Lmi | 57.6 | −22.8 | 30.5 | −61.9 | 207.0 | 16.6 | 7.2 | 13.8 | 16.5 | 7.5 |
| W Cen | −71.4 | −90.1 | 6.9 | 61.3 | 145.6 | 4.0 | 4.8 | 3.2 | 4.1 | 4.8 |
| U Cen | 11.1 | 10.4 | 66.9 | −41.8 | 238.0 | 5.7 | 5.3 | 5.7 | 5.6 | 5.4 |
| S UMa | −18.7 | −22.0 | 22.6 | 31.4 | 207.5 | 3.9 | 4.7 | 5.1 | 3.7 | 4.3 |
| U Vir | −47.5 | 46.3 | −20.2 | 29.1 | 279.8 | 11.0 | 13.5 | 7.1 | 11.5 | 10.7 |
| R Boo | −80.6 | −41.5 | −11.8 | 84.9 | 187.6 | 3.6 | 2.9 | 4.8 | 3.6 | 2.4 |
| T Nor | −43.8 | −8.6 | −7.5 | 31.1 | 224.5 | 5.3 | 4.4 | 4.1 | 5.3 | 5.7 |
| X CrB | −9.4 | −55.1 | −73.9 | 28.5 | 173.8 | 8.1 | 8.0 | 6.8 | 8.1 | 7.6 |
| U Ser | −86.3 | 51.4 | 43.5 | 102.7 | 276.8 | 32.2 | 37.2 | 39.3 | 32.7 | 24.5 |
| R Dra | −13.0 | −140.6 | −24.1 | 19.9 | 89.1 | 3.2 | 4.5 | 4.2 | 3.1 | 4.4 |
| RS Her | −36.3 | −56.2 | 62.1 | 51.3 | 171.0 | 6.0 | 5.6 | 6.2 | 5.9 | 5.9 |
| R Pav | 95.5 | −13.7 | 142.2 | −109.9 | 210.4 | 4.9 | 5.1 | 5.7 | 5.0 | 4.6 |
| T Pav | 39.8 | −43.4 | −25.7 | −54.0 | 184.0 | 5.8 | 5.9 | 5.3 | 5.7 | 5.1 |
| RU Sgr | −54.6 | −184.5 | 44.1 | 54.4 | 46.7 | 7.0 | 6.2 | 10.0 | 7.0 | 6.6 |
| T Aqr | 22.7 | −53.1 | 31.8 | −6.3 | 179.2 | 9.1 | 6.8 | 10.5 | 8.9 | 6.7 |
| RT Aqr | −99.7 | −50.7 | −34.4 | 105.4 | 177.1 | 7.0 | 5.5 | 5.8 | 7.0 | 3.3 |
| S Lac | 55.4 | −45.1 | 21.3 | −35.3 | 190.8 | 6.8 | 5.2 | 6.9 | 6.8 | 5.1 |
| V Cas | −2.2 | −30.8 | −14.8 | 11.7 | 199.8 | 2.9 | 4.8 | 3.1 | 2.8 | 4.7 |
| V Aqr | −13.6 | −13.5 | 40.1 | 20.9 | 216.9 | 3.7 | 3.8 | 2.9 | 3.7 | 3.9 |
| RU Cyg | 30.0 | 6.9 | 2.0 | −21.9 | 238.8 | 1.8 | 5.0 | 1.4 | 1.8 | 4.9 |
| *Group 4* | | | | | | | | | | |
| R Tri | −90.7 | −19.4 | 2.8 | 96.8 | 208.9 | 4.4 | 4.3 | 4.5 | 4.4 | 3.3 |
| T Eri | −74.7 | −65.4 | 51.5 | 67.3 | 168.8 | 4.2 | 3.7 | 4.7 | 4.1 | 3.9 |
| R Ret | −39.9 | −26.0 | 17.1 | 25.8 | 207.2 | 3.6 | 4.3 | 3.7 | 3.6 | 4.2 |
| X Gem | −29.9 | −38.9 | −17.7 | 28.5 | 192.3 | 5.1 | 4.5 | 6.0 | 5.1 | 3.5 |
| V Gem | −21.3 | −0.1 | −49.6 | 9.5 | 231.6 | 7.6 | 6.6 | 10.6 | 7.9 | 9.9 |
| V Cnc | −2.5 | −9.1 | −49.7 | −10.3 | 221.7 | 14.4 | 12.8 | 21.0 | 14.7 | 13.4 |
| S Hya | −76.4 | −11.0 | 34.7 | 58.7 | 225.3 | 10.5 | 6.3 | 12.4 | 10.6 | 6.5 |
| VW Oph | −19.7 | 93.9 | −287.8 | 89.6 | 312.9 | 48.4 | 107.5 | 170.6 | 43.7 | 149.3 |
| T Hya | −7.7 | 20.2 | −9.8 | −14.7 | 250.9 | 7.7 | 5.0 | 6.8 | 7.8 | 5.3 |
| V Leo | 44.7 | −34.5 | −17.3 | −54.8 | 193.9 | 17.4 | 8.8 | 14.1 | 17.2 | 5.8 |
| S Sex | 35.4 | −2.6 | 1.1 | −60.3 | 223.2 | 10.4 | 9.5 | 10.2 | 10.1 | 9.2 |
| T CVn | 0.6 | 14.9 | 15.6 | −0.1 | 245.9 | 6.0 | 1.0 | 5.0 | 6.0 | 1.2 |
| T UMa | 17.6 | −81.3 | −56.9 | −8.6 | 150.4 | 7.4 | 8.0 | 6.9 | 7.2 | 8.1 |
| RT Cen | −37.2 | −9.8 | −24.3 | 17.4 | 223.6 | 8.2 | 7.6 | 7.6 | 7.9 | 7.3 |
| Y Lib | 48.0 | −83.7 | −46.9 | −50.4 | 146.5 | 21.2 | 21.8 | 22.4 | 21.1 | 9.5 |
| RR Sco | −31.7 | −1.4 | 5.2 | 30.6 | 229.8 | 4.9 | 2.3 | 2.4 | 4.9 | 1.4 |
| R Aql | 75.1 | −16.7 | −32.3 | −71.0 | 215.7 | 3.8 | 3.4 | 1.1 | 3.9 | 3.5 |
| R Sgr | −38.2 | −34.1 | −43.7 | 44.7 | 195.5 | 5.4 | 5.5 | 7.8 | 5.4 | 4.9 |
| BG Cyg | −35.4 | −96.7 | −21.6 | 43.3 | 131.9 | 3.5 | 4.6 | 2.6 | 3.6 | 4.7 |

**Table 1** – *continued*

| Name | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ | $\sigma_u$ | $\sigma_v$ | $\sigma_w$ | $\sigma_{V_R}$ | $\sigma_{V_\theta}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| R Del | 43.9 | −79.5 | 10.8 | −32.0 | 154.5 | 10.3 | 7.1 | 8.8 | 9.9 | 7.7 |
| S Del | −19.7 | 7.8 | −0.6 | 41.4 | 236.0 | 7.0 | 4.9 | 5.5 | 6.9 | 5.1 |
| V Cap | 15.0 | −54.3 | 40.5 | −2.8 | 177.3 | 26.7 | 26.7 | 27.3 | 26.1 | 25.0 |
| T Cap | 51.6 | −58.1 | −64.8 | −36.6 | 176.6 | 12.7 | 7.9 | 12.1 | 12.6 | 6.6 |
| T Tuc | 14.0 | 15.9 | 72.1 | −30.0 | 245.5 | 4.7 | 4.0 | 5.0 | 4.7 | 4.2 |
| RT Boo | −14.9 | −19.5 | 73.3 | 27.6 | 210.2 | 5.0 | 6.1 | 5.8 | 5.1 | 6.5 |
| RS Dra | −38.8 | −28.3 | −8.7 | 55.4 | 198.9 | 3.5 | 4.6 | 3.5 | 3.4 | 4.5 |
| TY And | 16.9 | −6.3 | −20.4 | −0.6 | 225.3 | 4.2 | 4.9 | 3.6 | 4.1 | 4.7 |
| *Group 5* | | | | | | | | | | |
| Z Peg | −15.5 | −45.9 | 3.2 | 25.9 | 183.9 | 3.8 | 4.5 | 3.6 | 3.8 | 4.3 |
| SV And | 69.2 | −65.5 | 33.5 | −49.7 | 172.4 | 13.3 | 8.8 | 9.9 | 13.6 | 7.8 |
| U Per | −61.3 | −38.8 | −17.6 | 70.0 | 189.1 | 3.8 | 4.0 | 2.8 | 3.7 | 3.9 |
| *o* Cet | 55.9 | −49.2 | −97.3 | −55.6 | 181.9 | 2.7 | 0.7 | 4.3 | 2.7 | 0.6 |
| T Ari | 29.3 | 4.6 | −26.8 | −26.2 | 236.0 | 4.1 | 2.3 | 3.5 | 4.0 | 2.1 |
| RX Tau | 70.9 | −16.9 | −41.9 | −73.0 | 213.4 | 6.7 | 10.4 | 11.1 | 6.7 | 8.2 |
| S Col | −54.0 | −32.5 | −26.6 | 40.9 | 201.7 | 5.4 | 4.9 | 4.8 | 5.4 | 4.9 |
| V Mon | 44.0 | −76.5 | −21.4 | −49.6 | 152.8 | 4.5 | 3.8 | 3.8 | 4.4 | 3.5 |
| S CMi | −39.4 | −43.2 | −4.3 | 34.5 | 188.7 | 5.1 | 3.4 | 4.7 | 5.1 | 4.2 |
| AS Pup | 68.6 | 19.2 | 28.6 | −80.2 | 246.7 | 2.2 | 4.8 | 1.5 | 2.1 | 4.8 |
| R Car | −21.6 | −17.4 | −5.3 | 16.9 | 214.0 | 1.4 | 4.8 | 1.0 | 1.5 | 4.9 |
| X Hya | −77.1 | −49.3 | −78.9 | 68.7 | 185.1 | 5.4 | 4.6 | 5.3 | 5.3 | 4.5 |
| R Leo | 9.3 | −8.8 | 6.3 | −10.7 | 222.2 | 2.7 | 2.5 | 3.5 | 2.6 | 2.5 |
| V Ant | −20.8 | 19.8 | 22.3 | −5.4 | 251.6 | 7.1 | 5.3 | 7.6 | 7.1 | 5.4 |
| R UMa | −93.4 | −38.6 | 7.3 | 100.3 | 188.9 | 8.6 | 7.8 | 8.6 | 8.6 | 7.7 |
| X Cen | −42.7 | −51.9 | 0.7 | 31.1 | 181.5 | 4.9 | 5.0 | 4.1 | 4.9 | 5.0 |
| R Crv | 5.6 | 10.0 | −30.2 | −22.8 | 240.0 | 8.4 | 8.6 | 7.0 | 8.5 | 5.8 |
| R CVn | 11.3 | 3.3 | −2.6 | −7.2 | 234.4 | 0.8 | 2.7 | 4.8 | 0.8 | 2.9 |
| RX Cen | −14.2 | −46.6 | −48.4 | −6.3 | 184.8 | 24.7 | 23.9 | 21.7 | 23.0 | 16.4 |
| RU Hya | −0.8 | −78.7 | −80.6 | −7.6 | 152.1 | 6.5 | 6.7 | 7.2 | 6.4 | 6.1 |
| U UMi | 4.0 | 0.9 | −21.6 | 5.3 | 231.8 | 2.1 | 3.7 | 4.0 | 2.1 | 3.4 |
| S UMi | −4.5 | −61.9 | 8.8 | 10.5 | 168.8 | 2.3 | 3.9 | 3.3 | 2.2 | 3.8 |
| RU Lib | −65.0 | −35.3 | 33.1 | 61.2 | 196.9 | 15.7 | 20.1 | 20.9 | 15.5 | 13.2 |
| Z Sco | −45.9 | −3.9 | −14.6 | 43.0 | 227.7 | 6.3 | 8.1 | 8.8 | 6.3 | 9.9 |
| S Her | −5.2 | 42.6 | −24.4 | 15.5 | 273.2 | 3.9 | 3.2 | 3.9 | 4.0 | 3.9 |
| RS Sco | −4.6 | −30.4 | −79.7 | 1.1 | 200.6 | 5.1 | 2.9 | 3.5 | 5.1 | 6.0 |
| Z Oph | −94.3 | 80.8 | −48.4 | 137.9 | 295.1 | 6.2 | 10.0 | 12.8 | 6.2 | 10.1 |
| RV Sgr | 28.4 | −17.4 | −0.9 | −28.2 | 213.6 | 5.3 | 7.3 | 10.5 | 5.3 | 8.3 |
| X Oph | −63.8 | −22.3 | 26.1 | 67.6 | 207.5 | 11.3 | 15.5 | 20.8 | 11.1 | 13.2 |
| RT Aql | −6.4 | −42.0 | −29.9 | 17.2 | 188.3 | 5.2 | 5.0 | 5.9 | 5.2 | 5.0 |
| RR Sgr | 106.2 | 3.4 | 9.4 | −103.3 | 235.7 | 5.1 | 3.2 | 5.3 | 5.1 | 3.0 |
| RT Sgr | 40.2 | −27.3 | −5.7 | −39.7 | 203.8 | 6.7 | 4.3 | 8.5 | 6.7 | 5.2 |
| U Mic | −28.5 | −69.3 | 56.3 | 28.7 | 161.7 | 8.4 | 6.4 | 10.7 | 8.4 | 7.1 |
| TU Peg | 42.2 | −7.3 | 2.9 | −28.7 | 225.8 | 9.5 | 5.9 | 7.6 | 9.5 | 5.2 |
| X Aqr | 39.8 | −2.8 | 11.2 | −26.2 | 230.2 | 41.2 | 31.4 | 25.5 | 41.3 | 13.2 |
| W Peg | 10.1 | −13.4 | 13.8 | −1.9 | 217.8 | 2.2 | 4.4 | 3.0 | 2.2 | 4.3 |
| S Peg | 67.6 | −7.4 | −10.5 | −54.9 | 227.0 | 5.3 | 6.2 | 5.5 | 5.3 | 5.6 |
| TT Mon | 12.3 | −71.8 | 75.5 | −23.0 | 158.0 | 8.5 | 10.1 | 14.2 | 8.8 | 9.3 |
| VX Aur | −24.0 | 24.2 | −16.6 | 24.8 | 255.1 | 9.4 | 8.4 | 19.3 | 9.4 | 11.0 |
| UU Tuc | −54.5 | −31.3 | −59.7 | 36.3 | 203.8 | 13.1 | 10.9 | 9.4 | 12.6 | 11.0 |
| X Tel | 17.4 | 38.4 | 124.8 | −43.6 | 266.4 | 64.9 | 83.9 | 99.9 | 65.8 | 92.0 |
| *Group 6* | | | | | | | | | | |
| S Scl | −56.4 | 5.4 | −26.4 | 56.3 | 236.4 | 2.4 | 0.3 | 4.9 | 2.4 | 0.3 |
| R And | 64.0 | −10.7 | −47.9 | −54.9 | 222.8 | 9.1 | 6.9 | 4.7 | 9.2 | 6.0 |
| W And | 35.5 | −13.3 | 9.3 | −26.9 | 218.9 | 4.0 | 4.0 | 3.6 | 3.9 | 3.4 |
| R Hor | −75.0 | −113.6 | 32.1 | 72.8 | 118.7 | 0.7 | 2.9 | 4.3 | 0.7 | 2.9 |
| W Eri | 40.0 | 0.3 | −32.9 | −50.1 | 229.3 | 4.7 | 4.3 | 5.0 | 4.7 | 4.8 |
| R Cae | 13.1 | −1.7 | −14.9 | −22.8 | 228.5 | 3.8 | 4.1 | 4.0 | 3.7 | 3.9 |
| T Lep | 55.0 | −21.8 | 8.6 | −60.8 | 207.6 | 3.8 | 3.4 | 3.6 | 3.8 | 4.0 |
| U Dor | −57.9 | −69.1 | 30.8 | 46.3 | 165.6 | 4.7 | 4.7 | 4.4 | 4.7 | 4.7 |
| R Oct | −50.5 | −41.3 | −37.1 | 39.5 | 192.3 | 3.8 | 4.4 | 3.8 | 3.9 | 4.3 |
| U Ori | 34.6 | 17.1 | −11.6 | −35.8 | 247.9 | 4.9 | 2.1 | 2.6 | 4.9 | 1.9 |
| R Lyn | −13.2 | 16.0 | 5.1 | 19.8 | 246.5 | 4.8 | 5.1 | 6.4 | 4.8 | 9.2 |
| R Gem | 46.3 | 23.7 | −18.9 | −52.2 | 253.5 | 6.1 | 8.4 | 11.6 | 6.1 | 8.0 |
| R Cnc | −3.7 | −16.6 | 18.7 | 0.2 | 214.4 | 4.3 | 2.9 | 3.4 | 4.3 | 3.0 |
| W Cnc | −49.5 | −11.0 | 0.4 | 44.7 | 221.0 | 9.3 | 3.0 | 10.2 | 9.3 | 3.1 |
| R LMi | 12.5 | 4.0 | 14.4 | −13.6 | 234.9 | 4.4 | 2.1 | 4.6 | 4.4 | 2.0 |
| W Vel | −40.9 | −2.9 | 13.6 | 27.1 | 230.2 | 3.4 | 4.9 | 3.0 | 3.4 | 5.0 |
| R Com | −1.1 | 7.2 | −1.4 | −5.7 | 238.2 | 5.4 | 8.6 | 5.5 | 5.1 | 8.8 |
| R Hya | −23.7 | 3.6 | 12.0 | 21.6 | 234.8 | 2.8 | 2.9 | 3.2 | 2.9 | 2.9 |

**Table 1** – *continued*

| Name | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ | $\sigma_u$ | $\sigma_v$ | $\sigma_w$ | $\sigma_{V_R}$ | $\sigma_{V_\theta}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| S Vir | −14.8 | −0.5 | 21.9 | 9.8 | 230.8 | 3.4 | 2.7 | 4.3 | 3.4 | 2.4 |
| RS Vir | −22.8 | 16.0 | −0.4 | 21.5 | 247.1 | 4.8 | 2.5 | 4.9 | 4.8 | 1.7 |
| S Ser | 9.4 | 17.3 | 15.9 | −3.3 | 248.5 | 6.8 | 5.1 | 6.1 | 6.8 | 3.1 |
| U Her | −11.2 | −28.8 | 3.5 | 15.3 | 201.9 | 3.3 | 2.4 | 3.4 | 3.3 | 2.6 |
| T Sgr | 16.2 | −20.9 | −3.8 | −9.2 | 210.5 | 5.5 | 5.0 | 6.3 | 5.5 | 6.2 |
| RR Aql | 100.7 | −83.0 | 2.0 | −94.7 | 151.9 | 7.4 | 6.2 | 8.9 | 7.3 | 6.8 |
| T Cep | 67.1 | 9.7 | 6.3 | −61.9 | 242.1 | 1.4 | 4.7 | 1.4 | 1.3 | 4.7 |
| S Gru | −51.9 | −0.2 | −6.7 | 49.6 | 231.3 | 3.7 | 2.1 | 4.5 | 3.7 | 2.0 |
| R Peg | 0.0 | 0.0 | −28.7 | 10.2 | 230.8 | 3.0 | 4.6 | 4.3 | 3.1 | 4.3 |
| R Aqr | −14.0 | −46.8 | 9.7 | 15.8 | 184.1 | 1.1 | 2.2 | 4.7 | 1.1 | 2.0 |
| RT Eri | −25.0 | −7.3 | −12.3 | 21.6 | 224.1 | 5.0 | 3.8 | 5.0 | 5.0 | 2.4 |
| W Hya | 25.9 | −35.5 | 12.0 | −27.1 | 195.3 | 3.1 | 2.8 | 2.7 | 3.2 | 2.8 |
| BG Ser | −14.4 | 16.8 | 10.5 | 15.5 | 247.7 | 5.3 | 4.4 | 5.6 | 5.3 | 4.3 |
| AM Cyg | 15.9 | −75.2 | 8.9 | 1.3 | 156.6 | 15.2 | 7.5 | 17.3 | 14.6 | 6.3 |
| TV Cnc | −44.6 | −34.6 | −190.4 | 12.7 | 201.0 | 120.3 | 41.4 | 158.6 | 129.2 | 88.7 |
| *Group 7* | | | | | | | | | | |
| T Cas | −6.2 | −15.5 | −6.9 | 12.4 | 215.3 | 2.6 | 4.4 | 1.4 | 2.5 | 4.3 |
| S Pic | −13.2 | −10.6 | 12.2 | 0.6 | 220.8 | 3.5 | 4.7 | 4.6 | 3.5 | 4.7 |
| R Aur | −0.7 | −5.5 | −1.4 | 3.8 | 225.5 | 4.6 | 3.0 | 2.7 | 4.5 | 2.4 |
| S Ori | −1.3 | −29.6 | 14.7 | −2.9 | 201.4 | 4.7 | 4.6 | 5.5 | 4.7 | 4.9 |
| Z Pup | 15.9 | −17.3 | −2.8 | −33.8 | 211.6 | 19.0 | 8.5 | 9.2 | 19.9 | 14.8 |
| U CMi | −43.0 | −4.4 | 7.5 | 25.9 | 229.2 | 10.3 | 6.9 | 12.3 | 10.9 | 11.8 |
| Y Vel | −1.6 | 11.2 | 18.3 | −20.9 | 241.3 | 10.5 | 5.0 | 9.1 | 10.4 | 5.0 |
| WX Vel | −61.0 | −38.6 | 32.0 | 38.5 | 198.1 | 8.6 | 5.4 | 9.5 | 8.4 | 5.1 |
| R Cen | −28.7 | 20.5 | 2.8 | 20.2 | 252.4 | 3.7 | 3.8 | 1.5 | 3.8 | 3.9 |
| R Nor | −24.4 | 9.5 | 3.9 | 9.8 | 241.5 | 5.5 | 7.4 | 7.8 | 5.4 | 5.8 |
| RU Her | 3.5 | 2.9 | −23.4 | 4.3 | 233.9 | 3.9 | 3.5 | 4.4 | 3.9 | 4.3 |
| RX Vul | 60.8 | 0.7 | −5.6 | −41.1 | 236.0 | 5.6 | 5.0 | 4.4 | 5.6 | 5.0 |
| RS Peg | −40.0 | −34.6 | −22.8 | 54.6 | 192.8 | 9.6 | 6.4 | 8.5 | 9.7 | 6.2 |
| SS Peg | 6.1 | −7.8 | 18.4 | 11.3 | 223.0 | 6.4 | 5.2 | 5.9 | 6.5 | 5.3 |
| R Cas | −71.0 | −6.0 | 4.4 | 75.6 | 223.5 | 2.2 | 4.5 | 1.2 | 2.1 | 4.4 |
| RU Aur | 26.2 | −163.3 | 166.2 | −25.4 | 68.0 | 9.4 | 88.9 | 114.1 | 9.9 | 67.8 |

(b) Individual space velocities (km s$^{-1}$) for SP-red stars.

| Name | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ | $\sigma_u$ | $\sigma_v$ | $\sigma_w$ | $\sigma_{V_R}$ | $\sigma_{V_\theta}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| *Group 1* | | | | | | | | | | |
| SS Cas | 4.7 | −23.2 | −25.8 | 18.1 | 207.1 | 8.9 | 6.3 | 10.7 | 9.2 | 6.9 |
| W Pup | −76.6 | 7.6 | 59.1 | 46.0 | 246.3 | 7.1 | 5.0 | 4.5 | 7.2 | 5.2 |
| SS Her | 9.3 | −72.3 | −25.6 | 7.0 | 158.8 | 12.4 | 15.9 | 16.7 | 12.2 | 13.3 |
| SY Her | 154.3 | −20.7 | −59.4 | −126.8 | 227.9 | 7.8 | 7.2 | 8.1 | 7.5 | 7.8 |
| R Mic | 57.1 | 13.7 | 61.9 | −47.3 | 246.8 | 11.9 | 9.0 | 14.6 | 11.8 | 9.3 |
| R Vul | 5.1 | −0.6 | 14.8 | 23.4 | 229.3 | 5.1 | 4.9 | 4.5 | 5.1 | 4.9 |
| $L_2$ Pup | −113.7 | −36.9 | 89.5 | 111.7 | 195.2 | 1.3 | 4.7 | 1.4 | 1.2 | 4.7 |
| T Cen | −27.9 | −44.2 | 44.6 | 19.2 | 187.9 | 3.4 | 3.4 | 2.7 | 3.5 | 3.4 |
| W Cyg | −20.2 | −12.4 | −16.2 | 23.5 | 218.3 | 0.3 | 5.0 | 0.6 | 0.3 | 5.0 |
| *Group 2* | | | | | | | | | | |
| R Cet | −55.7 | 1.9 | 0.6 | 58.8 | 232.2 | 9.3 | 6.1 | 7.3 | 9.3 | 4.1 |
| R Vir | −26.6 | 4.9 | −19.1 | 20.6 | 236.5 | 2.1 | 3.5 | 4.8 | 2.2 | 2.9 |
| X Ara | −27.7 | −29.7 | −31.5 | 16.5 | 202.5 | 26.0 | 24.3 | 29.8 | 23.3 | 49.7 |
| RY Oph | −91.1 | 45.3 | 31.0 | 110.5 | 269.1 | 5.9 | 7.9 | 9.4 | 5.8 | 6.9 |
| RU Per | 34.1 | −33.8 | 2.8 | −27.4 | 198.3 | 7.0 | 9.4 | 9.6 | 7.2 | 9.3 |
| *Group 3* | | | | | | | | | | |
| RS Lib | 27.7 | 10.0 | −22.3 | −30.3 | 240.6 | 4.8 | 3.5 | 4.0 | 4.8 | 3.5 |

period range 145–200 d, show a net motion radially outwards in the Galaxy. This is interpreted as indicating a Galactic axial asymmetry and a concentration of orbits in a bar-like structure, which is an extension of the triaxial Galactic bulge to beyond the Solar circle.

## 2 ANALYSIS

The present discussion is restricted to Mira-like stars for which we can derive distances and space motions. Thus it is limited to stars for which we have $K$ photometry, proper motions and radial velocities. Distances were derived from the reddening-corrected $K$ magnitudes of Paper I together with a PL relation. Zero-points derived for different samples of Miras from *Hipparcos* parallaxes are given in Paper II. For our main sample of stars, which excludes the SP-red variables, we use the zero-point adopted in Paper II and the relation:

$$M_K = -3.47 \log P + 0.84. \quad (1)$$

This relation, when applied to Miras in the Large Magellanic

**Table 2.** Group motions ($km\,s^{-1}$) (SP-red stars omitted).

| Group | No. | $\bar{P}$ (d) | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ |
|---|---|---|---|---|---|---|---|
| 2 | 18 | 173 | $-73 \pm 17$ | $-97 \pm 20$ | $-11 \pm 11$ | $+75 \pm 18$ | $133 \pm 19$ |
| 3 | 24 | 228 | $-12 \pm 10$ | $-47 \pm 11$ | $+21 \pm 9$ | $+12 \pm 11$ | $184 \pm 11$ |
| 4 | 26 | 272 | $-8 \pm 8$ | $-27 \pm 6$ | $-5 \pm 7$ | $+8 \pm 8$ | $204 \pm 6$ |
| 5 | 40 | 324 | $-3 \pm 8$ | $-22 \pm 5$ | $-12 \pm 6$ | $+4 \pm 8$ | $209 \pm 5$ |
| 6 | 32 | 383 | $0 \pm 7$ | $-14 \pm 6$ | $0 \pm 3$ | $-1 \pm 7$ | $217 \pm 6$ |
| 7 | 15 | 453 | $-14 \pm 8$ | $-8 \pm 4$ | $+3 \pm 4$ | $+11 \pm 8$ | $223 \pm 4$ |
| 2 (−S Car) | 17 | 175 | $-65 \pm 16$ | $-83 \pm 14$ | $-12 \pm 12$ | $+67 \pm 17$ | $147 \pm 14$ |

**Table 3.** Dispersions ($km\,s^{-1}$) (SP-red stars omitted).

| Group | No. | $\bar{P}$ (d) | $\Sigma_w$ | $\Sigma_{V_R}$ | $\Sigma_{V_\theta}$ | $\Sigma_{V_\theta}/\Sigma_{V_R}$ | $\Sigma_w/\Sigma_{V_R}$ |
|---|---|---|---|---|---|---|---|
| 2 | 18 | 173 | $44 \pm 8$ | $73 \pm 12$ | $77 \pm 13$ | $1.06 \pm 0.25$ | $0.60 \pm 0.15$ |
| 3 | 24 | 228 | $44 \pm 6$ | $54 \pm 8$ | $53 \pm 8$ | $0.98 \pm 0.21$ | $0.82 \pm 0.16$ |
| 4 | 26 | 272 | $36 \pm 5$ | $42 \pm 6$ | $32 \pm 4$ | $0.76 \pm 0.14$ | $0.86 \pm 0.17$ |
| 5 | 40 | 324 | $35 \pm 4$ | $49 \pm 5$ | $32 \pm 4$ | $0.65 \pm 0.10$ | $0.71 \pm 0.11$ |
| 6 | 32 | 383 | $18 \pm 2$ | $39 \pm 5$ | $32 \pm 4$ | $0.82 \pm 0.15$ | $0.46 \pm 0.08$ |
| 7 | 15 | 453 | $13 \pm 3$ | $30 \pm 5$ | $16 \pm 3$ | $0.53 \pm 0.13$ | $0.43 \pm 0.12$ |
| 2 (−S Car) | 17 | 175 | $46 \pm 8$ | $67 \pm 12$ | $54 \pm 9$ | $0.81 \pm 0.20$ | $0.69 \pm 0.17$ |

Cloud (LMC), gives an LMC distance modulus of 18.64 mag, compared with the value of $18.70 \pm 0.12$ based on *Hipparcos* parallaxes of Cepheids (Feast & Catchpole 1997; Feast 1999) or $18.74 \pm 0.13$ based on Cepheid proper motions and radial velocities (Feast & Whitelock 1997; Feast, Pont & Whitelock 1998). The standard error of this zero-point is 0.14 mag (Paper II). For the SP-red stars we have used the relation:

$$M_K = -3.47 \log P + 0.40. \quad (2)$$

As discussed later, our conclusions are very insensitive to the values of the zero-points adopted.

The *Hipparcos* proper motions and their standard errors were converted into components in Galactic longitude and latitude ($\mu_{l*} = \mu_l \cos b$ and $\mu_b$) and their errors, using the constants provided in the *Hipparcos* catalogue and taking into account the correlations between the proper motions in right ascension and declination. Then if $\mu$ is a proper motion in milliarcseconds and $r$ the distance in kiloparsecs, the corresponding velocity is $\kappa\mu r$ $km\,s^{-1}$, where $\kappa = 4.74047$ (a value also taken from the *Hipparcos* catalogue). The procedure used in deriving the adopted radial velocities for the stars is described in Appendix A. These adopted radial velocities depend on both optical and radio (maser and non-maser emission-line) observations.

The observations were converted into the usual components of the space velocities: $u$, parallel to, and in the direction of, the Galactic Centre as seen from the Sun; $v$, at right angles to this in the Galactic plane, and in the direction of Galactic rotation; and $w$, perpendicular to the plane, in the direction of the north Galactic pole. Velocity components were also calculated in Galactocentric cylindrical coordinates: $V_R$, radially outwards from the Galactic Centre in the Galactic plane; and $V_\theta$, the rotational component in the plane (i.e. relative to a non-rotating point at the Solar position).[2] The third component in this system remains $w$. Where necessary we denote the distance of a star from the rotation axis of the Galaxy by $R_p$. The results have been corrected for local Solar motion ($u_0 = +9.3$, $v_0 = +11.2$ and $w_0 = +7.6\,km\,s^{-1}$) and a circular velocity of Galactic rotation of $231 \pm 15\,km\,s^{-1}$. A value of the distance to the Galactic Centre from the Sun ($R_0$) of 8.5 kpc was adopted. These various constants are discussed in Feast & Whitelock (1997) and Feast (2000). The resulting velocity components with their standard errors are given in Table 1. These results assume that the standard error of a radial velocity is $5\,km\,s^{-1}$. This value was estimated from the data discussed in Appendix A.

The stars are arranged in period groups in Table 1 (the mean periods of the groups are listed in Tables 2 and 3). These groups were chosen on the basis of earlier work using radial velocities which showed the run of kinematic properties with period (e.g. Feast et al. 1972). However, in the present work the SP-red stars identified in Papers I and II have been assigned to groups of their own and are discussed separately.

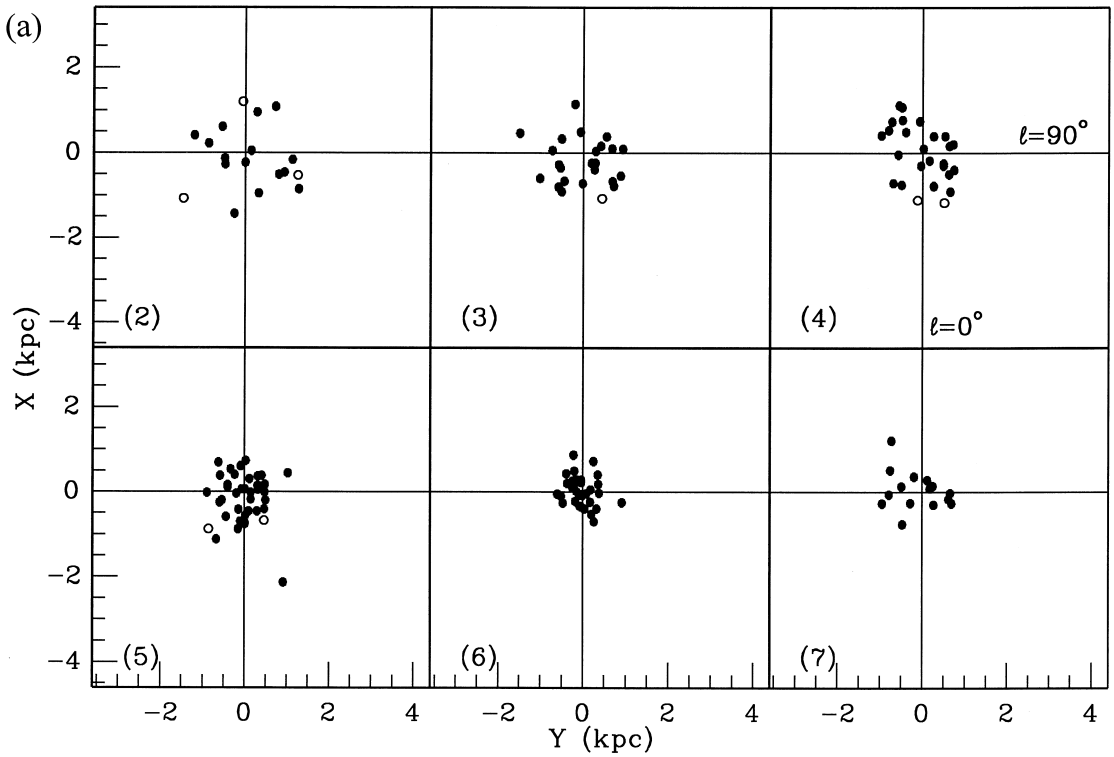
Mean velocities and velocity dispersions ($\Sigma_i$ where $i = w, V_R$ or $V_\theta$) were derived in each group and are listed in Tables 2 and 3. The mean values of $\Sigma_u$ and $\Sigma_v$ do not differ significantly from the values for $\Sigma_{V_R}$ and $\Sigma_{V_\theta}$, and are not tabulated. In this analysis we have omitted those stars for which the standard error of any velocity component is $50\,km\,s^{-1}$ or greater. In deriving the mean velocities, weights were assigned to the individual values depending on the standard errors listed in Table 1 and on the velocity dispersion of the group. For this, relations analogous to equations (4) and (5) of Feast & Whitelock (1997) were used. The mean velocities given in Table 2 were obtained by iteration. Initial values for the dispersions in the various groups were adopted from the earlier radial velocity work (Feast et al. 1972). For the final solution, a third-order polynomial fit was made to the various dispersions as a function of period.

Table 4 shows mean velocities in each period group with the PL zero-point changed by $\pm 0.5$ mag from the adopted value. In no case do these mean values differ significantly from the adopted values. Thus our final results and conclusions are not sensitive to the distance scale adopted. Solutions with the reddening estimates put to zero show that the results are also insensitive to the adopted reddenings. Similarly, adopting 0 or $10\,km\,s^{-1}$ instead of $5\,km\,s^{-1}$

[2] Note that, in the sign convention used, $V_R \equiv -u$ at the Solar position.

**Table 4.** Group motions ($km\,s^{-1}$): effect of distance scale change.

| Group | $\Delta M_K = +0.5$ mag | | | $\Delta M_K = -0.5$ mag | | |
|---|---|---|---|---|---|---|
| | $w$ | $V_R$ | $V_\theta$ | $w$ | $V_R$ | $V_\theta$ |
| 2 | $-13 \pm 9$ | $+64 \pm 15$ | $144 \pm 18$ | $-9 \pm 14$ | $+87 \pm 23$ | $123 \pm 21$ |
| 3 | $+16 \pm 8$ | $+9 \pm 9$ | $192 \pm 9$ | $+27 \pm 11$ | $+16 \pm 13$ | $175 \pm 13$ |
| 4 | $-3 \pm 6$ | $+6 \pm 7$ | $210 \pm 6$ | $-7 \pm 9$ | $+10 \pm 10$ | $196 \pm 7$ |
| 5 | $-9 \pm 5$ | $+2 \pm 7$ | $213 \pm 4$ | $-17 \pm 7$ | $+6 \pm 9$ | $202 \pm 6$ |
| 6 | $+1 \pm 3$ | $-2 \pm 6$ | $220 \pm 5$ | $-1 \pm 4$ | $+1 \pm 9$ | $213 \pm 7$ |
| 7 | $+4 \pm 3$ | $+9 \pm 6$ | $226 \pm 4$ | $+1 \pm 5$ | $+14 \pm 10$ | $220 \pm 5$ |



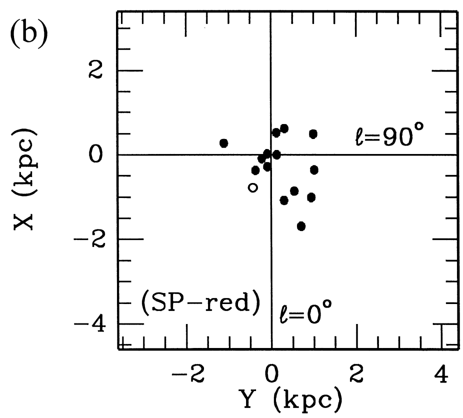




**Figure 1.** (a) The distribution of the Miras projected on to the Galactic plane, omitting the SP-red stars. The Sun is at the origin of the coordinate system. The group number is shown in the corner of each box. (b) The same as part (a) but for the SP-red stars.

for the standard error of a radial velocity makes no significant difference to the results. As one might have anticipated for a group of stars in the general Solar neighbourhood, the mean values of $u$ and $v$ are very similar in each group to the values of $-V_R$ and $V_\theta - 231$. In the following we concentrate on a discussion of $V_R$, $V_\theta$ and $w$, since these are the relevant quantities in Galactic terms. The distribution of the stars in each period group as projected on to the Galactic plane is shown in the various panels of Fig. 1. Fig. 2 shows the $V_\theta$ versus $V_R$ distributions in each group, and Fig. 3 shows the $V_\theta$ versus $w$ distributions. In these plots, stars for which a velocity component has a standard error greater than $20\,km\,s^{-1}$ are shown as open circles.

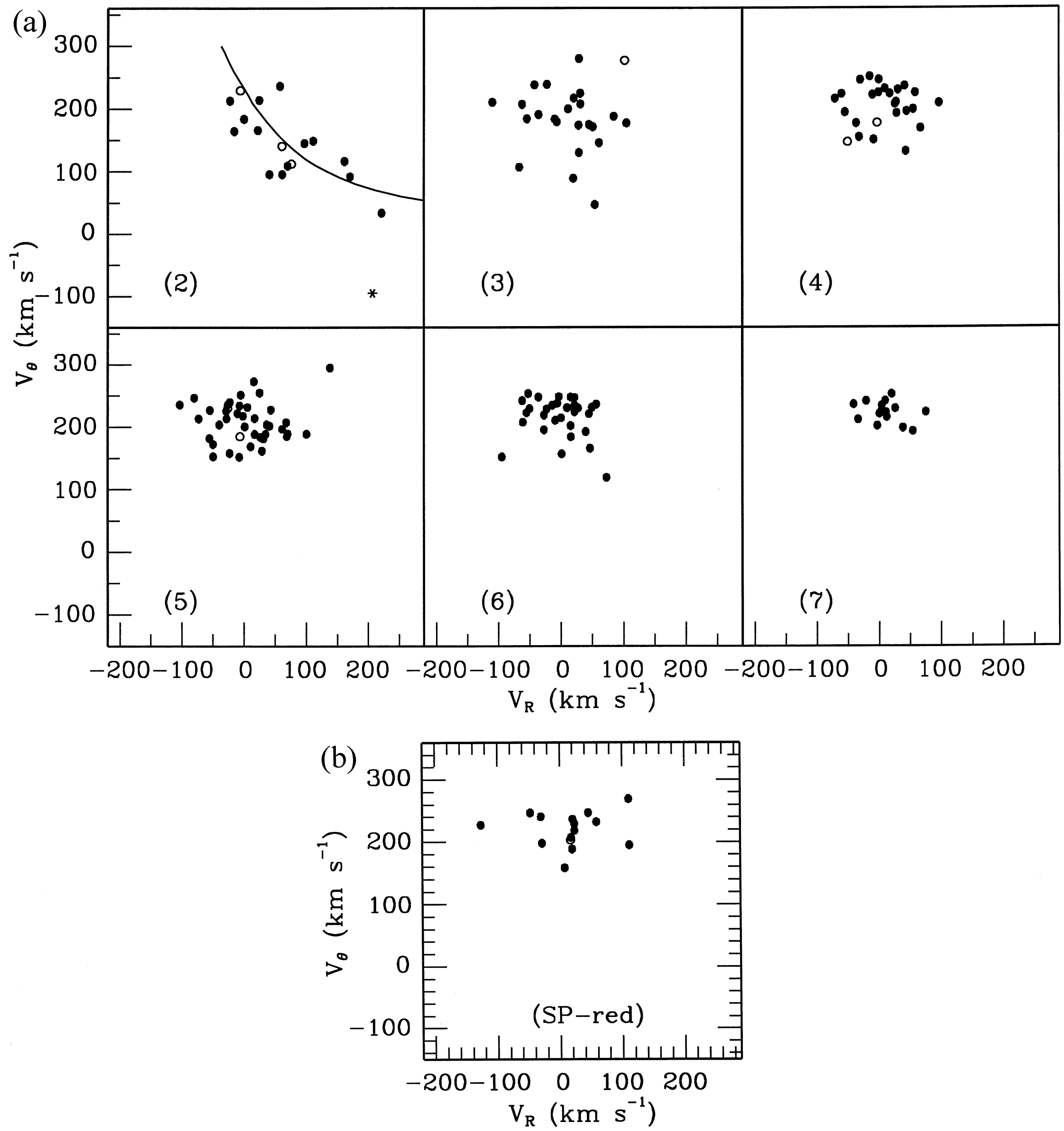


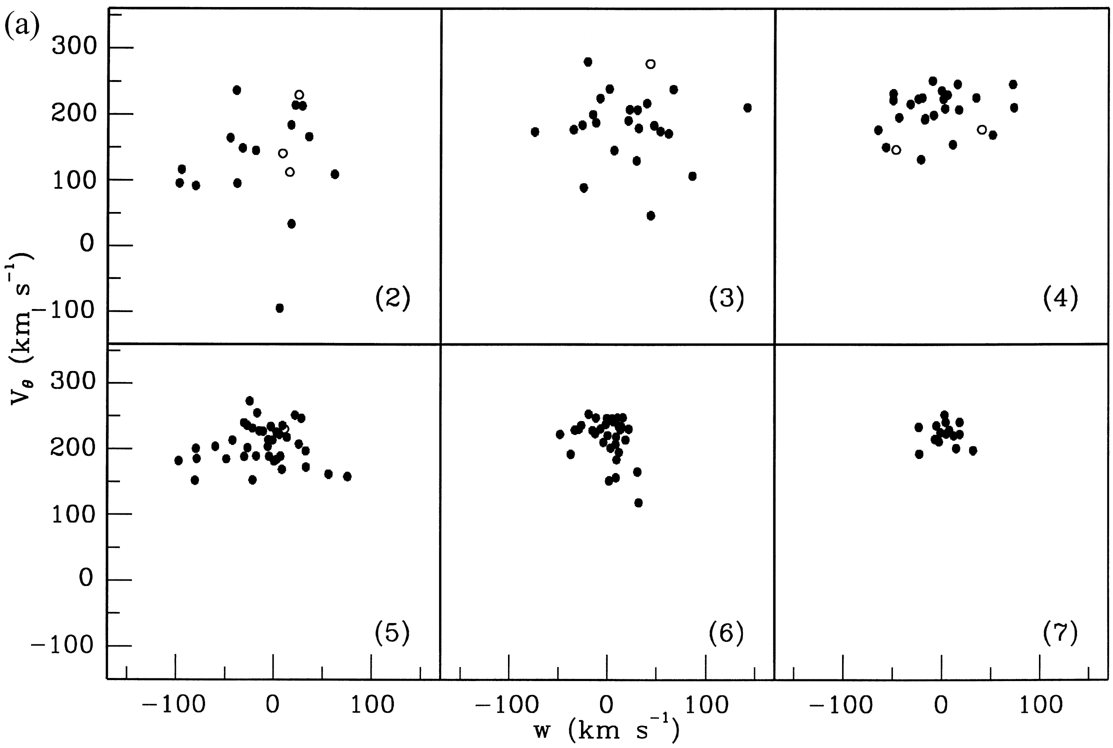

**Figure 2.** (a) Plots of $V_\theta$ against $V_R$ for the Miras in each group, omitting the SP-red stars. Stars for which a velocity component has a standard error greater than 20 km s$^{-1}$ are shown as open circles. The group number is shown in the lower left-hand corner of each box. In the plot of group 2 the asterisk denotes S Car and the curve shown is discussed in the text. (b) The same as part (a) but for the SP-red stars.

## 3 THE MIRA KINEMATIC SEQUENCE

The variations with period of the mean values of $V_R$ and $V_\theta$ and the various dispersions are shown in Figs 4 and 5. The progressive decrease in the rotational velocity ($V_\theta$) and the parallel increase in the velocity dispersions with decreasing period are generally similar to the results previously derived from (optical) radial velocities alone. These results show that the population to which a Mira-like variable belongs is a function of its pulsation period. This, together with the position of Miras in globular clusters at the tip of the asymptotic giant branch (AGB) and the dependence of the periods of Miras in globular clusters on the cluster metallicity, leads to the conclusion that the Mira period sequence is a sequence of the end-points of AGB evolution as a function of metallicity and possibly age (e.g. Feast & Whitelock 1987, 2000).

A main change from previous discussions concerns the group with periods less than 145 d. This group was always puzzling, since, instead of continuing the relation of kinematics to period found for the longer-period stars, it showed kinematics similar to much longer-period stars. It is, however, now clear from Papers I and II that these stars, in the main, form a distinct class (SP-red stars) in both colour and luminosity, and should not be thought of as part of the normal Mira sequence. These stars will be further discussed in Section 6.

At periods shorter than 145 d there are only two stars in our sample that we classify as SP-blue type, and which should, on the present hypothesis, be part of an extension of the normal Mira sequence to shorter periods, with lower $V_\theta$ and higher velocity dispersion. These stars are CI Vel ($P = 142$ d) and T Gru ($P = 136$ d). T Gru with a space velocity relative to the Sun of 276 km s$^{-1}$ and $V_\theta = 86$ km s$^{-1}$ obviously fits into such a category. The kinematic behaviour of CI Vel is less distinctive. It may be noted that T Gru would not have been recognized as having a high space velocity from its heliocentric radial velocity



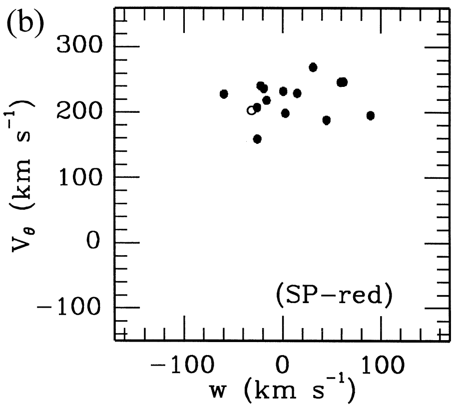




**Figure 3.** (a) Plots of $V_\theta$ against *w* for the Miras in each group, omitting the SP-red stars. Stars for which a velocity component has a standard error greater than 20 km s$^{-1}$ are shown as open circles. The group number is shown in the lower left-hand corner of each box. (b) The same as part (a) but for the SP-red stars.

alone, since this is only +13 km s$^{-1}$. If Miras in globular clusters are taken as a guide, we would not expect many normal Miras at periods as short as that of T Gru (136 d). The shortest-period star classed as a Mira-like object in a globular cluster is the star V1 in NGC 121 in the Small Magellanic Cloud (SMC), which has a period of 140.2 d (Thackeray 1958). Note the negative values of $V_R$ for T Gru and CI Vel.

## 4 EVIDENCE FOR A NON-AXISYMMETRIC GALAXY

One of the most remarkable features of Table 2 and Fig. 4 is the consistently positive value of $V_R$, indicating a net outward motion in the Galaxy. This result is particularly notable for group 2 (period range 145–200 d), which has $V_R = +75 \pm 18$ km s$^{-1}$. Fig. 2(a) plots $V_R$ against $V_\theta$ for this group. This plot shows that all but four of the stars in the group have positive values of $V_R$, and the absolute values of $V_R$ for these four stars are all quite small. The asymmetry in the values of $V_R$ in this group can also be seen in the histogram of Fig. 6. It is clear that as a group these stars are moving outwards in the Galaxy. If the Galaxy were axisymmetric, this would imply a large, real, symmetrical radial motion of this stellar population in the Galactic plane away from the Galactic Centre. This seems inherently unlikely. Equally unlikely seems the hypothesis that this group belongs to some other interacting satellite galaxy. The motion of this interloper would have to be almost exactly in the Galactic plane (see below) and it would also be unclear why there were no Galactic field Miras in this period range. We take the view that the present results provide, in fact, strong evidence for an asymmetry in stellar orbits. Since the group has a rotational velocity less than the circular velocity as well as a net outward velocity, it is easy to see that the kinematics point to a concentration of the current major axes of the Galactic orbits of

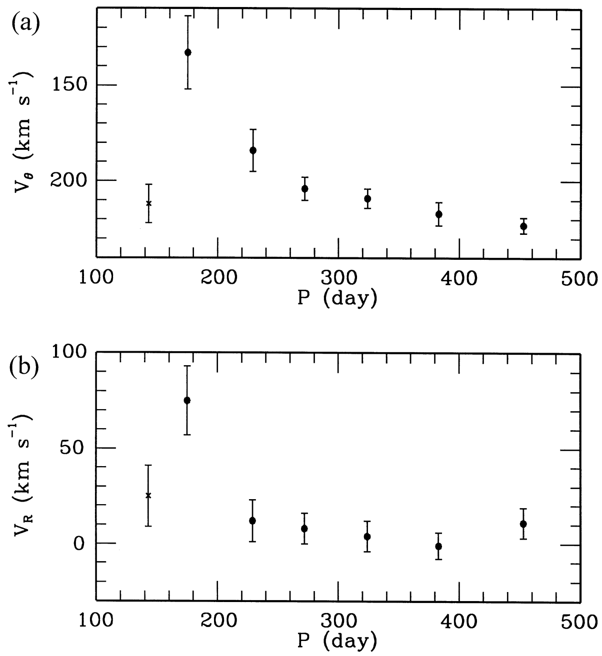



**Figure 4.** The variations with period of (a) the mean $V_\theta$ and (b) the mean $V_R$ for each group. The filled circles are for the groups of Table 2. The cross represents the SP-red stars.

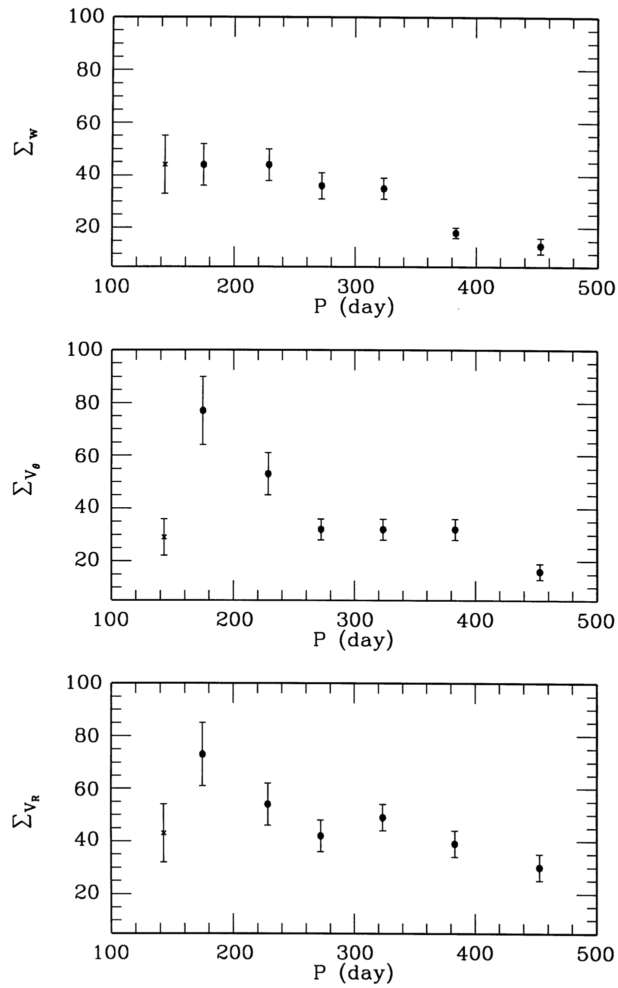



**Figure 5.** As Fig. 4, but illustrating the mean dispersions, in km s$^{-1}$, in the three coordinates.

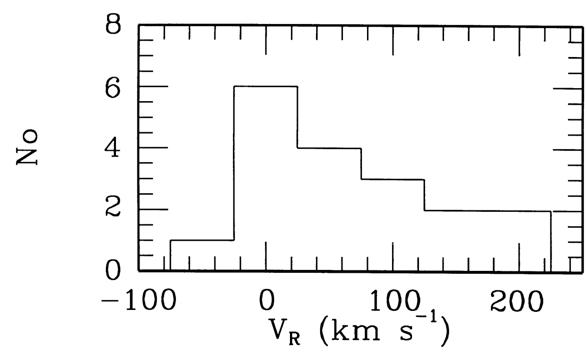



**Figure 6.** Histogram showing the distribution of $V_R$ in group 2 (SP-red stars omitted).

these Miras in the first quadrant of Galactic longitude, with the stars, in the mean, moving towards apogalacticum.

Whilst it would be desirable to do detailed calculations of orbits in a realistic, non-axisymmetric, potential, one can make a first approximate estimate of a mean orbit as follows. We consider the ‘mean’ group 2 Mira as moving in an ellipse under the influence of a centrally concentrated mass. Then given $V_R$ and $V_\theta$, and with $V_c$ as the circular velocity of Galactic rotation at $R_0$, it follows that

$$\cot\phi = (V_c^2 - V_\theta^2)/V_\theta V_R \quad (3)$$

and

$$e\cos\phi = 1 - (V_\theta/V_c)^2, \quad (4)$$

where $e$ is the eccentricity of the orbit and $\phi$ is the angle at the Galactic Centre between the Sun–Centre line and the major axis of the orbit (towards apogalacticum). The results for the group of mean period 175 d (group 2) then give:

$\phi = 16^{+10}_{-4}$ degrees,

$e = 0.69 \pm 0.12$.

One also finds that perigalacticum is at $1.7 \pm 0.8$ kpc and apogalacticum at $9.2 \pm 0.7$ kpc from the Centre. These results do not change significantly if the zero-point of the PL relation is changed by $\pm 0.5$ mag.

A somewhat better approximation is to use the Galactic potential given by Eggen et al. (1962) and displayed in a Bottlinger diagram by Sandage (1969). Using this model with their adopted value of $V_c$ and simply scaling from their adopted $R_0$ (10 kpc) to our adopted value gives a perigalacticum of 3.1 kpc, considerably larger than that derived on the point-mass approximation, as might be expected. Apogalacticum is at 9.1 kpc on this model, not significantly different from the point-mass model. Neither of the above models is realistic, especially if there is significant mass in a bar. There remains considerable uncertainty in the parameters of the non-axisymmetric potential applicable to our Galaxy. Some recent work is mentioned below, and it would be valuable to see whether our first estimate of $\phi$ from Miras can be improved by a more sophisticated approach.

In deriving the above figures, the star S Car was included in group 2. With $V_R = +206 \pm 2$ km s$^{-1}$, $V_\theta = -95 \pm 5$ km s$^{-1}$ and $w = +6 \pm 2$ km s$^{-1}$, this star is obviously on a highly eccentric retrograde orbit. If we omit this star from group 2, we obtain the velocity components given in Table 2 and

$\phi = 17^{+11}_{-4}$ degrees,

$e = 0.62 \pm 0.10$.

Thus our general conclusions regarding group 2 would not be changed. In contrast to S Car, R Pic, another member of group 2, is on a similar, high-eccentricity, but direct, orbit. In Fig. 2(a) there is a rather clear correlation of $V_\theta$ with $V_R$ in group 2. We expect such a correlation if the major axes of the orbits are aligned. The curve in the figure shows the expected correlation if the simple approximation of equation (3) holds and $\phi = 17°$. Note that the point at $V_\theta = -95$ is for S Car and should be ignored for this comparison.[3]

It is clear from Table 2 and Fig. 4 that the mean value of $V_R$ drops rapidly as one moves from group 2 to Miras of longer period. The results would be consistent with a gradual decrease of $V_R$ with increasing period though groups 3 to 7, but the evidence is marginal. The mean result for these five groups is $V_R = +5.8 \pm 2.4\,\mathrm{km\,s^{-1}}$, indicating a small asymmetry in the same sense as that of group 2.

Thus the kinematics indicate that the major axes of the orbits of the group 2 Miras in the general Solar neighbourhood are concentrated to the first quadrant of Galactic longitude. There is considerable evidence for a triaxiality in the Galactic bulge – see for instance recent summaries by Tiede & Terndrup (1999) and Sevenster et al. (1999). This evidence will not be recapitulated here, but, in view of the fact that the present paper deals with Mira variables, it is useful to note that one of the earliest pieces of evidence for a triaxial bulge was the space distribution of Mira variables in the bulge region derived from individual distances using a PL relation (Whitelock & Catchpole 1992). Whilst all the evidence on the structure of the bulge has not yet been completely reconciled, authors agree that the major axis of the bulge lies nearest the Sun in the first quadrant of Galactic longitude. This, then, clearly suggests that the concentration of Mira orbits that we have found is an extension of this bar-like distribution out to the Solar radius and beyond.

Using the Bottlinger diagram of Sandage (1969), adjusted as described above, one finds that about half the stars in group 2 have perigalactic distances of $\sim$2 kpc or less. It seems likely therefore that these stars penetrate into the Galactic bulge.

Although it is agreed by all workers that the long axis of the bulge–bar is in the first quadrant of Galactic longitude, a range of viewing angles have been proposed. A recent summary of derived angles has been given by Sevenster et al. (1999, their section 5). The values range from 16°, derived from the gas dynamics of the central region (Binney et al. 1991), to 44°, derived by Sevenster et al. themselves from radial velocities of OH/IR stars and a Galactic model. There are several determinations that give values in the 20° to 30° range. Our value agrees with that of Binney et al. and would be consistent with somewhat larger values (e.g. in the 20° to 30° range). It is not consistent with the Sevenster et al. value.

As Table 2 shows, the *w* component of the mean motion is not significantly different from zero in any of the groups except, possibly, in group 3. It is $-11 \pm 11\,\mathrm{km\,s^{-1}}$ in group 2, and the weighted mean over all groups is $0 \pm 3\,\mathrm{km\,s^{-1}}$. If the mean orbit of any group was at an angle to the Galactic plane, then the orbital velocity would have a component in the direction of the Galactic pole, which would be apparent in the *w* velocity. Group 2, which shows a low value of $V_\theta$ and a large positive $V_R$, is particularly interesting in this respect. The observed (total) orbital velocity is $153 \pm 26\,\mathrm{km\,s^{-1}}$. If the orbit were inclined to the Galactic plane, this would be a minimum value. It then follows that the maximum angle at which the mean orbit of group 2 can be tilted from the plane is $-4° \pm 4°$, where the minus sign indicates that the mean orbit is below the Galactic plane on the Solar side of the Galactic Centre. This is consistent with the results of Dwek et al. (1995), who found, from *COBE* DIRBE observations, a maximum possible tilt of $-2°$ for the central bulge ellipsoid. Both their result and ours are consistent with zero tilt.

Regarding a local bar-like structure, it may be of relevance to note that some samples of subdwarfs appear to show signs of an excess of out-going Galactic orbits. This can be seen for instance in fig. 23 of Sandage & Fouts (1987), which plots what was regarded as a 'thick disc' sample,[4] although this was not commented on at the time. Raboud et al. (1998) find that a sample of high proper motion stars with significant asymmetrical drift contain an excess of outward-moving stars and interpret this in terms of a bar model. Dehnen (1998, 1999, 2000) obtains somewhat similar results and interprets them in terms of a bar with an outer Lindblad resonance near $R_0$. The effect we find in our group 2 is much more extreme in velocity space than that found in other, less homogeneous, groups of stars. For instance the group 2 Miras would be confined to a narrow locus in the *u*,*v* plane, at the edge of the distribution of old disc stars shown in fig. 3 of Dehnen (1998).

## 5 VELOCITY DISPERSIONS

Velocity dispersions corrected for observational scatter were derived in the manner described by, e.g., Spaenhauer, Jones & Whiteford (1992). The values and their ratios are listed in Table 3. Whilst a full discussion would need to take account of the non-axisymmetric distribution of orbits, a number of general points can be made regarding these results. If one obtains mean dispersions averaged over the six groups (weighting the squares of the dispersions by the number of stars involved), one finds $\bar{\Sigma}_w = 34 \pm 2$, $\bar{\Sigma}_{V_R} = 49 \pm 3$ and $\bar{\Sigma}_{V_\theta} = 42 \pm 2$. These values, together with a similarly weighted asymmetric drift of $V_c - \bar{V}_\theta = 33 \pm 10\,\mathrm{km\,s^{-1}}$, are not too different from conventional values for the thick disc (Freeman 1987), viz. 40, 70, 49 and 30–40 $\mathrm{km\,s^{-1}}$, though the value of $\bar{\Sigma}_{V_R}$ is low. However, this comparison does not consider the net positive $V_R$ and the change of kinematic characteristics with period. In fact, the division of Miras by period would seem to provide a finer division into kinematically homogeneous groups than is obtained from most discriminants used to define, e.g., the thick disc.

The ratios $\Sigma_{V_\theta}/\Sigma_{V_R}$ and $\Sigma_w/\Sigma_{V_R}$ (Table 3) show some evidence of a systematic variation with period. Particularly in the shorter-period groups these ratios are large compared with those for many groups of stars (see e.g. the data in Mihalas & Binney 1981, their table 7.1). The result for $\Sigma_{V_\theta}/\Sigma_{V_R}$ in group 2 is significantly affected if S Car, which has a retrograde orbit, is omitted (see Table 3). Note that, in view of the correlation of $V_R$ with $V_\theta$ in group 2, the dispersions in this group, at least, cannot be directly

[3] It should be emphasized that we are concerned here in presenting the evidence for an alignment of the Galactic orbits of the group 2 stars and with obtaining in a simple way some estimate of the angle of the orbital major axis. Many authors have considered, in a general way, orbits in barred potentials, and the referee has suggested as one possibility that the group 2 stars are on aligned oval orbits that are symmetrical about the Galactic Centre.

[4] Note the different sign convention in *u* compared with the present paper.

**Table 5.** Group motions ($km\,s^{-1}$) (SP-red stars).

| Group | No. | $\bar{P}$ (d) | $u$ | $v$ | $w$ | $V_R$ | $V_\theta$ |
|---|---|---|---|---|---|---|---|
| 1 | 9 | 125 | $-1 \pm 26$ | $-20 \pm 9$ | $+16 \pm 17$ | $+8 \pm 22$ | $214 \pm 9$ |
| 2 | 5 | 162 | $-33 \pm 21$ | $-2 \pm 14$ | $-2 \pm 10$ | $+36 \pm 23$ | $229 \pm 13$ |
| all | 15 | 143 | $-10 \pm 17$ | $-11 \pm 7$ | $+8 \pm 11$ | $+15 \pm 15$ | $221 \pm 7$ |
| 1 (−SY Her) | 8 | 125 | $-21 \pm 19$ | $-20 \pm 10$ | $+26 \pm 16$ | $+25 \pm 16$ | $212 \pm 10$ |
| all (−SY Her) | 14 | 145 | $-22 \pm 13$ | $-11 \pm 8$ | $+13 \pm 10$ | $+25 \pm 12$ | $221 \pm 8$ |

**Table 6.** Dispersions ($km\,s^{-1}$) (SP-red stars).

| Group | No. | $\bar{P}$ (d) | $\Sigma_w$ | $\Sigma_{V_R}$ | $\Sigma_{V_\theta}$ |
|---|---|---|---|---|---|
| 1 | 9 | 125 | $50 \pm 12$ | $65 \pm 15$ | $28 \pm 7$ |
| 2 | 5 | 162 | $18 \pm 9$ | $50 \pm 16$ | $17 \pm 21$ |
| all | 15 | 143 | $41 \pm 7$ | $59 \pm 11$ | $24 \pm 7$ |
| 1 (−SY Her) | 8 | 126 | $44 \pm 11$ | $43 \pm 11$ | $29 \pm 7$ |
| all (−SY Her) | 14 | 145 | $38 \pm 7$ | $45 \pm 9$ | $25 \pm 7$ |

compared with those expected for axisymmetrical systems. The dispersion of group 2 in $V_\theta$, corrected for observational error, about the line shown in Fig. 2(a) is $46 \pm 8\,km\,s^{-1}$. Also we might naively expect a decrease in $\Sigma_{V_R}$ relative to the values that would be found in an equivalent axisymmetrical population. Evidently the lack of in-going orbits at the Sun, relative to out-going orbits (an almost total lack of in-going orbits in group 2) will lead to a lower $\Sigma_{V_R}$ than would be obtained for a symmetrical distribution of orbits. For instance in group 2 the dispersion calculated about $V_R = 0$ is $107\,km\,s^{-1}$ compared with the actual value ($73\,km\,s^{-1}$) given in Table 3. Fig. 6 shows a histogram of the individual values of $V_R$ in group 2. The small number of stars involved precludes any strong conclusions regarding the distribution of these values, but they do appear to be quite asymmetric, with a sharp drop at $V_R \sim 0$.

The value of $\Sigma_w$ in group 2 is slightly, but not significantly, larger than that of the conventional thick disc. One can therefore adopt (see e.g. Freeman 1987) an exponential scaleheight of about 1 kpc or perhaps slightly more for this component. This can be taken as a measure of the (half-)thickness of the Galactic bar in the Solar neighbourhood (note that the Sun is off-centred from the bar). The scaleheight decreases with increasing period, as the eccentricity of the orbits decrease.

## 6 THE SHORT-PERIOD RED VARIABLES

Some discussion of the kinematics of the SP-red stars was given in Paper I using radial velocity data. Table 1 lists SP-red stars for which we have infrared photometry, radial velocities and *Hipparcos* proper motions. We have analysed these data in the same way as for the SP-blue and other Miras in the earlier parts of this paper. Results for the various Galactic kinematic constants are listed in Tables 5 and 6, and were derived in a similar way to those in Tables 2 and 3. As in the case of the other Mira groups discussed earlier, the mean kinematics derived are not significantly affected by a change in the adopted PL zero-point of $\pm 0.5$ mag.

With the obvious caveat that small numbers of stars are involved, we may draw the following conclusions from Tables 5 and 6: (1) The SP-red star in group 1 do not extend the Mira kinematic sequence to higher asymmetric drifts. (2) The SP-red stars in group 2 have a higher Galactic rotational velocity than SP-blue stars in the same period range (Table 2). In Tables 5 and 6, results are given with and without SY Her, which has a high space velocity and a considerable effect on the mean values.

Discussion of the SP-red stars is more complex (and uncertain) than for the SP-blue stars and the normal Mira sequence to which they belong. For these latter stars we know there is a narrow PL relation, and globular clusters lead us to conclude that there is a strong correlation between period and population type (specifically, chemical abundance – Feast & Whitelock 2000). However, we cannot assume that this is true for the SP-red stars. If, as suggested in Paper I, these stars are analogous to the SR variables in metal-rich globular clusters and are on evolutionary tracks that terminate with Miras, there will be a range of periods possible for any given kinematic population. Different SP-red stars of the same period may be evolving into Miras of different periods and thus belong to different kinematic groups. The situation is further complicated by the possibility that some of the SP-red stars may be in a temporary, fainter phase of their helium-shell flash cycle. Despite this, we can say that the SP-red stars are distinct from the normal Mira sequence and are kinematically associated with (a range of) longer-period Miras. Whether they are pulsating in the same mode as normal Miras or in an overtone remains uncertain, although the results of Paper II point to the first alternative.

**Table 7.** Radial gradients.

| Group | $\bar{P}$ (d) | $dV_R/dR_p$ | $dV_\theta/dR_p$ |
|---|---|---|---|
| 2 | 173 | $-3 \pm 25$ | $-16 \pm 28$ |
| 3 | 229 | $-19 \pm 20$ | $-12 \pm 19$ |
| 4 | 272 | $+11 \pm 14$ | $+13 \pm 11$ |
| 5 | 324 | $-25 \pm 13$ | $-16 \pm 9$ |
| 6 | 383 | $-24 \pm 24$ | $+21 \pm 16$ |
| 7 | 453 | $-1 \pm 24$ | $-11 \pm 11$ |
| 5 (−Z Oph) | | $-6 \pm 16$ | $-5 \pm 11$ |

## 7 TEST FOR VELOCITY GRADIENTS

Figs 7 and 8 show plots, for each group, of $V_R$ and $V_\theta$ against $R_p$, the distance of a star from the Galactic rotation axis. Estimates of $dV_R/dR_p$ and $dV_\theta/dR_p$ (in units of $km\,s^{-1}\,kpc^{-1}$) were made by fitting straight lines to the observations through the mean points for each group. The results are given in Table 7. Because of the limited range in $R_p$ and the relatively high velocity dispersions, the data do not place any very useful limits on these gradients except to show that they do not differ significantly from zero. The exception to this statement might be the value of $dV_R/dR_p$ in group 5. However, as is evident in Fig. 7(a) the value of $dV_R/dR_p$ derived for this group depends heavily on one point. This is Z Oph, which has abnormal colours for its period (see Paper I). The results without this star show no significant gradient. The mean gradients, weighting the groups by the number of stars they contain, are $dV_R/dR_p = -8 \pm 5\,km\,s^{-1}\,kpc^{-1}$ and

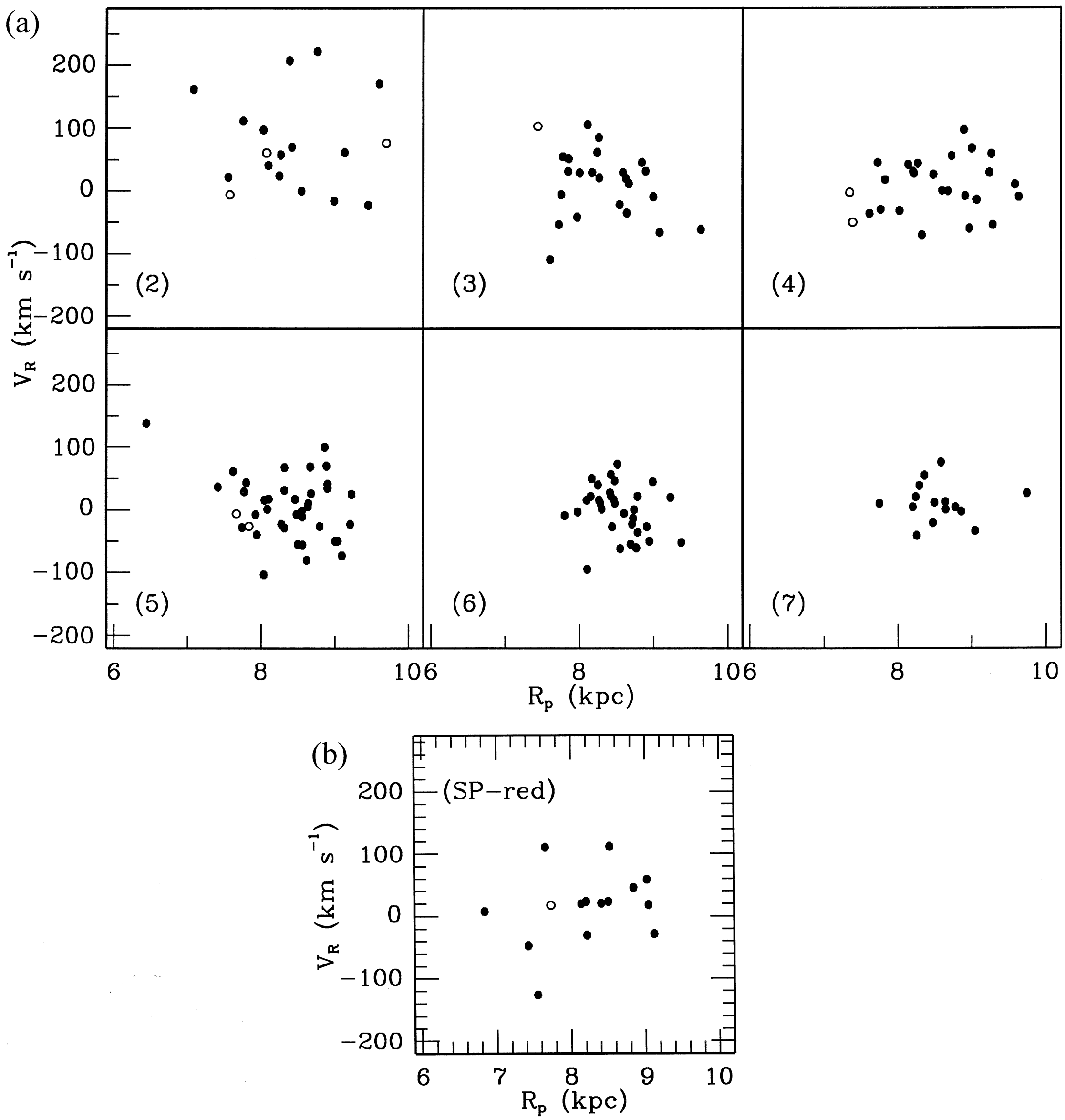



**Figure 7.** (a) Plots of $V_R$ against $R_p$, the distance of a star from the Galactic rotation axis. Symbols and division into groups as in Fig. 2 (SP-red stars omitted). (b) The same as part (a) but for the SP-red stars.

$dV_\theta/dR_p = 0 \pm 6\,km\,s^{-1}\,kpc^{-1}$, and are thus not significantly different from zero.

## 8 CONCLUSIONS

The space motions of Mira variables derived from radial velocities and *Hipparcos* proper motions confirm and strengthen the previously known dependence of mean Galactic rotational velocity and velocity dispersions on period. In addition we find that Miras in the period range 145–200 d show a net radial motion outwards in the Galaxy. We interpret this, together with the observed rotational velocity, as indicating a Galactic axial asymmetry. The results indicate a concentration of orbits with major axes in the first quadrant of Galactic longitude and at a viewing angle from the Galactic Centre of $\sim 17°$. A significant number of Miras with periods in the range 145–200 d have orbits that probably penetrate into the Galactic bulge. We interpret the asymmetry in the Mira orbits as indicating an extension of the bar seen in the Galactic bulge, out to beyond the Solar circle.

The Miras, being old, but relatively short-lived objects ($\sim 2 \times 10^5$ yr; Whitelock & Feast 1993), must be tracers of a much larger population of stars. It is clearly of particular interest to identify and study objects which may be associated with Miras in the period range 145–200 d. The globular cluster results (Feast & Whitelock 2000) suggest that such objects will have metallicities in the range $-0.8 \gtrsim [Fe/H] \gtrsim -1.3$ and the ages of globular clusters in this metallicity range.[5] Prime candidates are obviously subsets of RR Lyrae variables and subdwarfs. However, the situation may be complex, especially if there is a significant range in the ages of globular clusters of a given metallicity. Note

[5] Both the absolute and relative ages of globular clusters of different metallicities remain a subject of current debate.

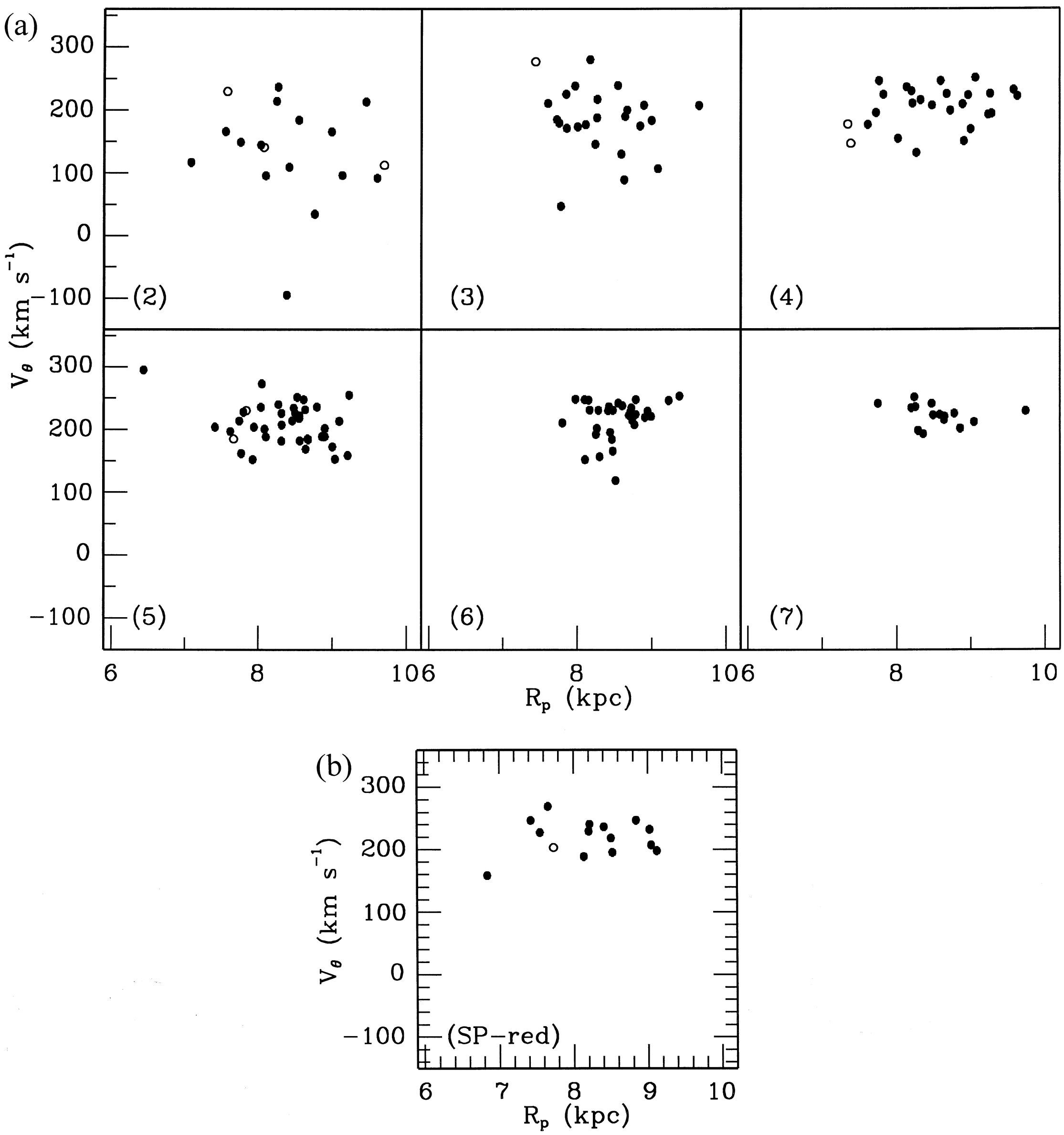



**Figure 8.** (a) Plots of $V_\theta$ against $R_p$, the distance of a star from the Galactic rotation axis. Symbols and division into groups as in Fig. 2 (SP-red stars omitted). (b) The same as part (a) but for the SP-red stars.

that Minniti et al. (1997) have suggested that the RR Lyraes in the Galactic bulge are not part of the bar-like population. It may thus be that Miras, which can be divided by period into homogeneous groups of age, metallicity and kinematic characteristics, are the best objects for studying these phenomena.

The space motions of the separate group of SP-red Mira-like variables are shown to be consistent with the interpretation of these stars discussed in Papers I and II.

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## APPENDIX A: MEAN RADIAL VELOCITIES OF OXYGEN-RICH MIRA-LIKE VARIABLES

A comprehensive catalogue of the radial velocities of Mira variables was published many years ago (Feast 1963). Since that time a great deal of further work has been done, particularly in the radio (millimetre and submillimetre) region. For the purposes of the present paper, an updated catalogue was required. The literature was therefore searched for radial velocity measurements of oxygen-rich Mira-like variables. A useful initial source of

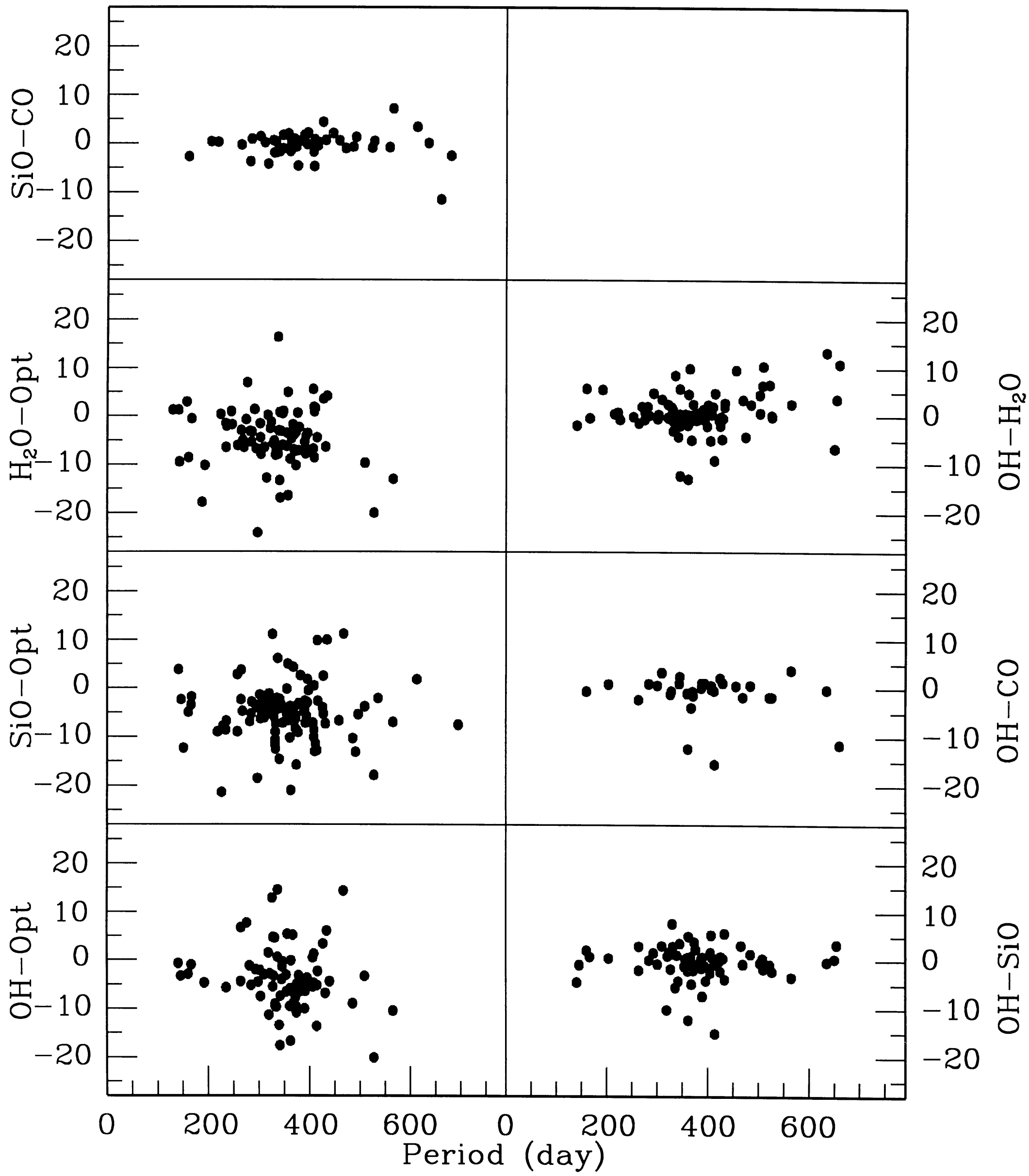


**Figure A1.** The differences between radial velocities measured in various ways as a function of period.

reference (although it does not give velocities) is the catalogue of stellar masers by Benson et al. (1990). In the case of optical data, the adopted measures refer to absorption lines. Where only optical emission lines were measured, these were reduced to effective absorption-line velocities as described by Feast (1963) or in the equivalent scheme of Smak & Preston (1965). For a few stars there are rather extensive studies of the variation of (optical) radial velocities with phase, with excitation level of the lines used, etc. In some cases a mean was taken of such measures. In others, we have preferred to use a velocity from one of the few major optical radial velocity programmes on Miras. This gives greater confidence that all the results are on the same system. The radio observations depend on both masing and non-masing emission lines and involve the molecules OH, $H_2O$, SiO, CO and (for a few stars) SO.

In the case of OH, the maser lines are generally double-peaked. The standard model for this structure (e.g. Habing 1996) indicates that the mean of the two peaks is the true radial velocity of the star, and the zero-point of the system adopted here is based on these means. For a significant number of stars there are measures of radial velocity by two or more different methods. These are used in the comparisons shown in Fig. A1. Mean differences based on the data in these figures are given in Table A1. Within the

**Table A1.** Radial velocity comparisons (km $s^{-1}$).

| Method | No. | Mean difference | Dispersion |
|---|---|---|---|
| OH−optical | 77 | $-3.9 \pm 0.7$ | 6.4 |
| OH−$H_2O$ | 95 | $+0.8 \pm 0.4$ | 4.1 |
| OH−SiO | 72 | $-0.4 \pm 0.4$ | 3.6 |
| OH−CO | 33 | $-1.1 \pm 1.0$ | 5.7 |
| SiO−optical | 107 | $-4.9 \pm 0.6$ | 5.9 |
| $H_2O$−optical | 87 | $-4.5 \pm 0.6$ | 5.9 |
| SiO−CO | 51 | $-0.2 \pm 0.4$ | 2.6 |

**Table A2.** Radial velocities.

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| R And | 409 | M | S | −18 | 0.01 | Op,SiO,CO | 1,10,14,44,49 |
| T And | 280 | M | Me | −89 | 3.12 | Op | 1,28 |
| U And | 346 | M | Me | −10 | | Op | 1 |
| V And | 257 | M | Me | +15 | | Op | 1 |
| W And | 395 | M | S | −35 | 0.56 | Op,SiO,CO | 1,14,24,32,49 |
| X And | 346 | M | Se | −9 | 3.05 | Op | 1 |
| Y And | 220 | M | Me | −9 | | Op | 1 |
| RR And | 328 | M | Se | −77 | 3.08 | Op | 1 |
| RU And | 238 | SRa | Me | −45 | | Op | 2 |
| RW And | 430 | M | M/S | −21 | 1.81 | Op | 1 |
| RY And | 393 | M | M8 | −8 | 2.09 | OH,$H_2O$ | 30,53 |
| SV And | 316 | M | Me | −97 | 2.60 | Op,SiO | 5,15,32 |
| SX And | 333 | M | Me | −73 | 2.47 | Op | 1 |
| TV And | 113 | SRb | Me | −59 | | Op | 1 |
| TY And | 260 | SRb | Me | −9 | 1.65 | Op | 2 |
| UZ And | 314 | M | Me | −43 | | Op | 1 |
| YY And | 227 | M | Me | −93 | | Op | 3 |
| AH And | 480 | M | Me | −16 | 2.90 | Op | 3 |
| AI And | 326 | M | | −95 | | Op | 3 |
| AX And | 379 | M | | −16 | | Op | 3 |
| BP And | 141 | M | | −89 | | Op | 3 |
| BU And | 382 | M | Me | −13 | 0.65 | $H_2O$ | 30 |
| EY And | 360 | M | M | −50 | 1.95 | OH,$H_2O$,SiO | 29,30,54 |
| KU And | 750 | | M | −28 | 2.70 | CO | 44 |
| T Aps | 261 | M | Me | +64 | 3.34 | Op | 1 |
| WW Aps | 267 | M | Me | +11 | 3.45 | Op | 1 |
| V Ant | 302 | M | Me | −4 | 2.10 | Op,OH,$H_2O$ | 1,29,43,45,55 |
| R Aqr | 387 | M | M/P | −23 | 1.02 | Op,SiO | 1,6,14,15,32,56,57,58 |
| S Aqr | 279 | M | Me | −59 | 2.68 | Op | 1 |
| T Aqr | 202 | M | Me | −41 | 3.24 | Op | 1 |
| V Aqr | 244 | SRb | Me | −44 | 0.58 | Op,$H_2O$ | 1,30 |
| W Aqr | 381 | M | Me | −16 | 1.71 | Op,SiO | 1,15,32,58 |
| X Aqr | 311 | M | S/M | +7 | 2.95 | Op | 1 |
| Z Aqr | 135 | SRa | Me | +66 | 3.66 | Op | 1 |
| RR Aqr | 182 | M | Me | −184 | 5.57 | Op | 1 |
| RT Aqr | 246 | M | Me | −35 | 2.17 | Op | 1 |
| SS Aqr | 192 | M | Me | +2 | 4.82 | Op | 48 |
| TX Aqr | 346 | M | | −26 | 5.66 | Op | 3 |
| XX Aqr | 334 | M | M4 | −62 | 3.84 | OH | 35 |
| AV Aqr | 251 | M | M? | −75 | 6.81 | Op | 3 |
| HY Aqr | 310 | | M8 | −20 | 4.87 | Op | 48 |
| R Aql | 284 | M | Me | +30 | 0.76 | Op,OH,$H_2O$,SiO,CO | 1,6,9,10,13,14,24,27,28,29,30,31,32,43,57,58 |
| S Aql | 146 | Sra | Me | −108 | 4.32 | Op | 5 |
| W Aql | 490 | M | Se | −37 | 0.61 | Op,SiO,CO | 1,5,14,44,57 |
| X Aql | 347 | M | Me | −27 | 2.71 | Op | 1 |
| Z Aql | 129 | M | Me | −7 | 5.18 | Op,$H_2O$ | 1,8,59 |
| RR Aql | 394 | M | Me | +13 | 0.50 | Op,OH,$H_2O$,SiO,CO | 5,9,14,29,30,31,32,40,43,44,49,58 |
| RS Aql | 410 | M | Me | −2 | 2.22 | Op,$H_2O$ | 1,15 |
| RT Aql | 327 | M | M/S | −47 | 1.13 | Op,OH,$H_2O$,SiO,CO | 1,16,24,30,31,32,43,58 |
| RU Aql | 274 | M | Me | +19 | 3.03 | Op | 1 |
| RV Aql | 218 | M | Me | −73 | 4.32 | Op | 5 |
| RX Aql | 206 | M | | +66 | | Op | 3 |
| SS Aql | 148 | M | M6 | −18 | | Op | 3 |
| SU Aql | 393 | M | S | +49 | | Op | 3 |
| SV Aql | 252 | M | | −68 | | OH,$H_2O$ | 19,20,34 |
| SW Aql | 247 | M | | +6 | | Op | 3 |
| SY Aql | 355 | M | Me | −67 | 2.24 | Op,OH,$H_2O$,SiO | 1,19,20,27,29,30,31,43,56 |
| TU Aql | 270 | M | M | −59 | 2.36 | Op | 3 |
| TV Aql | 243 | M | Me | −55 | | Op | 3 |
| WZ Aql | 316 | M | Mep | +16 | 2.25 | Op | 3 |
| XY Aql | 423 | M | M8 | −62 | 2.98 | Op | 3 |
| AK Aql | 298 | M | Me | −57 | | Op | 3,46 |
| EU Aql | 321 | M | M | +56 | 2.59 | $H_2O$ | 8 |
| GK Aql | 196 | M | | +32 | | Op | 3 |
| GO Aql | 154 | M | | −46 | | Op | 3 |
| GY Aql | 204 | SR | Me | +18 | 0.31 | OH,SiO,CO | 14,36,44,56,58,60 |
| QU Aql | 607 | M | Se | +25 | 4.02 | Op | 3 |
| V335 Aql | 177 | M | Me | +8 | 6.84 | Op | 3 |
| V386 Aql | 334 | M | M | +30 | 4.06 | Op | 3 |
| V397 Aql | 183 | M | | +72 | | Op | 3 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| V430 Aql | 266 | M | | +77 | | Op | 3 |
| V436 Aql | 285 | M | Me | −24 | | Op | 3 |
| V437 Aql | 192 | M | | +20 | | Op | 3 |
| V438 Aql | 279 | M | Me | −11 | | Op | 3 |
| V442 Aql | 308 | M | M | −44 | | Op | 3 |
| V455 Aql | 350 | M | M | −89 | 4.04 | OH,$H_2O$ | 19,20,34 |
| V456 Aql | 350 | M | | +10 | | Op | 3 |
| V466 Aql | 428 | M | M | −7 | | Op | 3 |
| V503 Aql | 138 | M | | −88 | | Op | 3 |
| V514 Aql | 291 | M | | −73 | | Op | 3 |
| V517 Aql | 305 | M | | +20 | | Op | 3 |
| V530 Aql | 366 | M | | +23 | | Op | 3 |
| V533 Aql | 354 | M | | +44 | | Op | 46 |
| V540 Aql | 308 | M | | −84 | | Op | 3 |
| V545 Aql | 243 | M | | −85 | | Op | 3 |
| V580 Aql | 150 | M | Me | −39 | 5.00 | Op | 3 |
| V581 Aql | 215 | M | | +46 | | Op | 3 |
| V592 Aql | 197 | M | | −61 | | Op | 3 |
| V595 Aql | 241 | M | | +40 | | Op | 3 |
| V635 Aql | 166 | M | | −25 | | OH | 34 |
| V671 Aql | 221 | M | | +54 | | Op | 3 |
| V707 Aql | 259 | M | | −113 | | Op | 3 |
| V867 Aql | 195 | M | | −47 | | Op | 3 |
| V893 Aql | 316 | M | Me | −46 | | Op | 3 |
| V1133 Aql | 405 | M | | +32 | | OH | 16 |
| V1300 Aql | 680 | | M | −32 | 2.30 | SiO,CO | 44,58 |
| U Ara | 225 | M | Me | −73 | 3.67 | Op | 1 |
| X Ara | 175 | M | Me | −9 | 2.42 | Op | 1 |
| RR Ara | 205 | M | Me | −49 | | Op | 1 |
| R Ari | 186 | M | Me | +104 | 3.93 | Op,$H_2O$ | 1,15,59 |
| S Ari | 292 | M | Me | −30 | 4.63 | Op | 1 |
| T Ari | 316 | SRa | Me | +4 | 0.17 | Op,SiO,CO | 2,15,24,61 |
| U Ari | 371 | M | Me | −44 | 1.22 | Op,OH,SiO,CO | 1,24,32,43,58 |
| Z Ari | 339 | M | M | −47 | | Op | 3 |
| RU Ari | 353 | M | M | +28 | 3.37 | Op,OH,$H_2O$ | 3,8,12,17,19,20,29,43 |
| YZ Ari | 447 | | M8 | +25 | 3.66 | OH | 37,51 |
| R Aur | 457 | M | Me | +1 | 0.94 | Op,SiO,CO | 1,24,32,44,49 |
| U Aur | 408 | M | Me | +15 | 0.99 | Op,OH,$H_2O$,SiO,CO | 1,24,30,43,61 |
| W Aur | 274 | M | Me | −133 | 3.14 | Op | 1 |
| X Aur | 163 | M | Me | −21 | 3.23 | Op | 1 |
| RR Aur | 307 | M | Me | +22 | | Op | 1 |
| RS Aur | 170 | SRa | Me | +15 | | Op | 1 |
| RU Aur | 466 | M | Me | −31 | 1.02 | Op,OH,SiO | 1,41,43,56 |
| SW Aur | 309 | M | | +10 | | Op | 3 |
| SZ Aur | 454 | M | Me | +14 | 1.18 | Op,SiO | 3,41 |
| VX Aur | 322 | M | M4 | +21 | 1.66 | Op | 3 |
| VY Aur | 402 | M | M7e | +19 | 2.72 | Op | 3 |
| AC Aur | 311 | M | Me | −25 | 2.69 | Op | 3 |
| AQ Aur | 334 | M | M7 | +44 | 2.89 | SiO | 41 |
| AW Aur | 695 | M | M | −2 | 2.34 | Op,SiO | 3,41 |
| AY Aur | 186 | M | M | −17 | 2.86 | Op | 3 |
| BN Aur | 136 | M | | +12 | | Op | 3 |
| BS Aur | 462 | M | M | +27 | 2.33 | SiO | 41 |
| BT Aur | 560 | M | M | −6 | | Op | 3 |
| DT Aur | 169 | M | | +8 | | Op | 3 |
| GN Aur | 253 | M | | −40 | | Op | 3 |
| GU Aur | 217 | M | | −29 | | Op | 3 |
| NV Aur | 635 | | M | +2 | 3.18 | OH,SiO,CO,$H_2O$ | 26,29,32,36,37,44,62,63 |
| R Boo | 223 | M | Me | −59 | 2.11 | Op,$H_2O$ | 1,30 |
| S Boo | 270 | M | Me | −18 | | Op | 1 |
| U Boo | 201 | SRb | Me | +17 | 5.39 | Op | 1 |
| V Boo | 258 | SRa | Me | −41 | 0.90 | Op | 1 |
| Z Boo | 281 | M | Me | +38 | 3.71 | Op,OH,$H_2O$ | 1,15,31 |
| RR Boo | 194 | M | Me | −46 | 5.28 | Op | 1 |
| RT Boo | 273 | M | Me | +35 | 2.56 | $H_2O$ | 15 |
| RX Boo | 340 | SRb | Me | −12 | 1.93 | Op,$H_2O$,SiO,CO,SO | 6,9,10,14,18,25,30,31,32,33,44,58 |
| R Cae | 391 | M | Me | +22 | 0.59 | Op,OH,$H_2O$,SiO | 1,43,54,55,64 |
| R Cam | 270 | M | Se | −37 | | Op | 1 |
| T Cam | 373 | M | Se | −15 | 0.41 | Op,SiO | 1,14 |
| V Cam | 522 | M | Me | +1 | 1.49 | OH,$H_2O$,SiO,CO | 10,14,30,36,40,43,49,53 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| X Cam | 143 | M | Me | +12 | | Op | 1 |
| RT Cam | 366 | M | Me | −38 | 2.13 | $H_2O$ | 8 |
| TX Cam | 557 | M | M | +11 | 0.36 | SiO,CO,SO | 10,14,32,33,36,40,44,49,56 |
| R Cnc | 361 | M | Me | +28 | 0.62 | Op,OH,$H_2O$,SiO,CO | 1,14,24,28,30,32,43,57,58 |
| U Cnc | 304 | M | Me | +68 | 4.64 | Op | 1 |
| V Cnc | 272 | M | Se | −9 | 3.14 | Op | 42 |
| W Cnc | 393 | M | Me | +43 | 1.04 | Op,$H_2O$,SiO,CO | 1,10,14,24,30,32,56 |
| RS Cnc | 120 | SRc? | M/S | +13 | 1.70 | CO | 49 |
| SZ Cnc | 319 | M | M | −24 | | Op | 3 |
| TV Cnc | 366 | M | M7 | −10 | 4.63 | Op | 3 |
| UY Cnc | 228 | M | M | −17 | 2.99 | $H_2O$ | 15 |
| R CVn | 328 | M | Me | −12 | 0.63 | Op,SiO | 1,15,28,32,56 |
| T CVn | 290 | | M/S | +9 | 2.04 | Op | 46 |
| U CVn | 345 | M | Me | −33 | 2.84 | Op,OH,$H_2O$ | 1,30,31,43 |
| V CVn | 191 | SRa | Me | −8 | 1.22 | Op,OH,$H_2O$ | 1,8,30,60 |
| RT CVn | 253 | M | Me | −12 | | Op | 1 |
| SU CMa | 248 | M | M | −14 | | Op | 3 |
| TT CMa | 314 | M | S | +59 | 3.51 | SiO | 41 |
| DL CMa | 345 | M | Me | +51 | | $H_2O$ | 15 |
| S CMi | 332 | M | Me | +65 | 0.48 | Op,SiO,CO | 1,10,24,56 |
| T CMi | 328 | M | Me | +31 | 3.97 | Op | 1 |
| U CMi | 413 | M | Me | +51 | 2.61 | Op | 1 |
| V CMi | 366 | M | Me | +33 | 1.98 | Op | 1 |
| UW CMi | 340 | M | | +10 | | Op | 3 |
| VV CMi | 334 | M | | +74 | | Op | 3 |
| VX CMi | 272 | M | Me | +46 | | Op | 3 |
| WW CMi | 176 | M | | +79 | | Op | 3 |
| WY CMi | 274 | M | | +41 | | Op | 3 |
| WZ CMi | 316 | M | | +57 | | Op | 3 |
| T Cap | 269 | M | Me | +42 | 3.24 | Op | 1 |
| V Cap | 275 | M | Me | −37 | 3.47 | Op | 1 |
| W Cap | 209 | M | Me | +12 | | Op | 1 |
| Z Cap | 181 | M | Me | −65 | 5.24 | Op | 1 |
| RR Cap | 277 | M | Me | −64 | 3.33 | Op | 1 |
| RU Cap | 347 | M | Me | −3 | 2.82 | OH | 43 |
| TX Cap | 129 | M | Me | +8 | | Op | 3 |
| R Car | 308 | M | Me | +23 | 1.35 | Op,SiO | 1,65 |
| S Car | 149 | M | Me | +283 | 1.87 | Op | 1 |
| RZ Car | 272 | M | Me | 0 | 3.19 | Op | 1 |
| R Cas | 430 | M | Me | +18 | 1.79 | Op,OH,$H_2O$,SiO,CO,SO | 1,6,10,14,24,28,30,31,32,33,36,40,43,44,49,57,58 |
| S Cas | 612 | M | Se | −41 | 1.93 | Op,SiO,CO | 1,14,44,49,57 |
| T Cas | 444 | M | Me | −14 | 1.04 | Op,SiO,CO | 1,10,14,24,32,44,58 |
| U Cas | 277 | M | Se | −48 | 2.45 | Op | 1 |
| V Cas | 228 | M | Me | −35 | 0.92 | Op,SiO | 1,32,66 |
| Y Cas | 413 | M | Me | −22 | 1.18 | Op,OH,$H_2O$,SiO,CO | 1,10,14,30,31,32,43,58 |
| Z Cas | 495 | M | Me | −38 | 2.04 | Op,SiO | 1,32,56,58 |
| RR Cas | 300 | M | Me | −49 | | Op | 1 |
| RV Cas | 331 | M | Me | −74 | 2.07 | Op,SiO | 1,32 |
| SS Cas | 140 | M | Me | −22 | 3.24 | Op | 1 |
| TY Cas | 645 | M | M | −67 | 3.13 | $H_2O$ | 30,31 |
| WY Cas | 476 | M | Se | +2 | 2.42 | $H_2O$,SiO | 14,15 |
| EO Cas | 455 | M | Se | −51 | | SiO | 14 |
| IW Cas | 396 | M | Se | −24 | | Op | 3 |
| R Cen | 546 | M | Me | −33 | 0.70 | Op | 1 |
| T Cen | 90 | SRa | Me | +29 | 2.50 | Op | 1 |
| U Cen | 220 | M | Me | +10 | 3.13 | Op | 1 |
| W Cen | 201 | M | Me | +56 | 1.95 | Op | 1 |
| X Cen | 315 | M | Me | +36 | 1.11 | Op,SiO | 1,50 |
| RS Cen | 164 | M | Me | +55 | 3.48 | Op | 1 |
| RT Cen | 255 | M | Me | −30 | 2.69 | Op | 1 |
| RX Cen | 327 | M | Me | −2 | 2.77 | Op,OH | 1,43 |
| TW Cen | 269 | M | Me | +3 | 1.80 | Op,$H_2O$ | 1,64 |
| VV Cen | 199 | M | Me | +3 | 4.82 | Op | 1 |
| VX Cen | 307 | | Se | −59 | 0.50 | Op | 1 |
| AL Cen | 125 | SRa | Me | +96 | 3.72 | Op | 2 |
| AQ Cen | 387 | M | Me | +2 | 1.68 | OH,SiO | 15 |
| V370 Cen | 403 | M | M | +24 | 1.83 | SiO | 50 |
| V491 Cen | 202 | SR? | Me | −52 | | Op | 1 |
| T Cep | 388 | M | Me | −16 | 1.70 | Op,OH,SiO,CO | 1,10,14,15,24,28,32,44,57,58 |
| X Cep | 535 | M | Me | +16 | 2.40 | Op,SiO | 1,32 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| Y Cep | 332 | M | Me | −4 | | Op | 1 |
| RT Cep | 621 | M | M | −53 | 1.49 | CO | 44 |
| RY Cep | 149 | M | Me | −120 | | $H_2O$ | 59 |
| AG Cep | 445 | M | Me | −8 | 2.51 | $H_2O$ | 12 |
| AM Cep | 333 | M | M | −63 | 1.69 | OH,$H_2O$ | 15,30,31 |
| CU Cep | 700 | M | M | −63 | 2.03 | $H_2O$ | 8 |
| GH Cep | 331 | M | M | +24 | 2.48 | $H_2O$ | 8 |
| R Cet | 166 | M | Me | +41 | 2.54 | Op,OH,$H_2O$,SiO | 1,8,43,66,67 |
| S Cet | 320 | M | Me | +29 | 3.30 | Op | 1 |
| U Cet | 234 | M | Me | −31 | 2.77 | Op,$H_2O$,SiO | 1,30,66 |
| V Cet | 257 | M | Me | +50 | 4.23 | Op | 1 |
| W Cet | 351 | M | Se | +7 | 2.09 | Op | 1 |
| X Cet | 177 | M | Me | +58 | 4.23 | Op | 1 |
| Z Cet | 184 | M | Me | +1 | 3.18 | Op | 1 |
| RY Cet | 374 | M | Me | +12 | 2.71 | Op | 3 |
| *o* Cet | 332 | M | Me | +58 | 2.45 | Op,$H_2O$,SiO,CO | 1,8,10,14,24,28,30,32,44,49,56,58 |
| R Cha | 334 | M | Me | −20 | | Op | 1 |
| R Col | 327 | M | Me | +65 | 2.71 | Op | 1 |
| S Col | 325 | M | Me | +79 | 1.60 | Op,OH,SiO | 1,38,43 |
| T Col | 225 | M | Me | +54 | 1.96 | Op,SiO | 1,15 |
| UV Col | 445 | | M9e | −5 | 3.19 | Op | 48 |
| UW Col | 316 | | M8 | +48 | 4.03 | Op | 48 |
| R Com | 362 | M | Me | −7 | 2.21 | Op,OH,$H_2O$,SiO | 5,30,43,66 |
| T Com | 406 | M | Me | +15 | 3.13 | Op,OH,$H_2O$ | 3,19,27,29,30,31,43 |
| U CrA | 147 | M | Me | −23 | | Op | 1 |
| RR CrA | 280 | M | Me | −91 | | Op | 1 |
| RY CrA | 195 | M | Me | +21 | 6.87 | Op | 1 |
| RZ CrA | 460 | M | Me | −91 | | Op | 1 |
| UX CrA | 347 | M | Me | −40 | | Op | 1 |
| YY CrA | 125 | M | Me | +70 | | Op | 1 |
| AM CrA | 187 | SR | Me | −39 | 0.23 | Op | 2 |
| S CrB | 360 | M | Me | −14 | 0.32 | Op,OH,$H_2O$,SiO,CO | 1,6,10,13,14,24,25,28,29,30,31,43,44,58 |
| W CrB | 238 | M | Me | +18 | | Op | 1 |
| X CrB | 241 | M | Me | −105 | 3.66 | Op | 1 |
| Z CrB | 250 | M | Me | −81 | 4.15 | Op | 1 |
| RY CrB | 90 | SRb | M10 | +21 | 1.35 | $H_2O$ | 68 |
| R Crv | 317 | M | Me | −26 | 1.88 | Op | 1 |
| T Crv | 401 | M | Me | −24 | 2.66 | Op | 3 |
| U Crv | 283 | M | Me | +10 | 4.34 | Op | 3 |
| V Crv | 193 | M | Me | +187 | 7.40 | Op | 3 |
| ST Crv | 224 | M | | +70 | | Op | 3 |
| R Crt | 160 | SRb | M7 | +18 | 1.28 | Op,OH,$H_2O$,SiO,CO | 6,7,9,10,13,14,15,18,25,30,31,60 |
| S Crt | 155 | SRb | Me | +42 | 0.77 | $H_2O$ | 30,31 |
| RT Crt | 342 | M | M | +37 | 4.49 | Op | 3 |
| R Cyg | 426 | M | Se | −33 | 1.33 | Op,SiO | 1,14 |
| S Cyg | 322 | M | Se | −22 | | Op | 1 |
| W Cyg | 131 | SRb | Me | −21 | 1.38 | Op,CO | 1,47 |
| Z Cyg | 263 | M | Me | −166 | 2.46 | Op,OH,$H_2O$,SiO,CO | 1,8,24,28,29,30,31,43,66 |
| RT Cyg | 190 | M | Me | −118 | 3.28 | Op | 1,5 |
| RU Cyg | 233 | SRa | Me | −7 | 0.02 | Op | 2 |
| ST Cyg | 337 | M | Me | −18 | 2.68 | Op | 1 |
| SX Cyg | 411 | M | Me | −16 | 2.10 | Op,SiO | 1,32 |
| TU Cyg | 219 | M | Me | −83 | | Op | 1 |
| TY Cyg | 349 | M | Me | +47 | | Op | 46 |
| UX Cyg | 565 | M | Me | −16 | 1.97 | Op,OH,$H_2O$,SiO,CO | 1,27,29,30,31,32,43,44,53,58 |
| AC Cyg | 142 | SRb | M7 | −54 | 0.32 | Op,$H_2O$ | 8,30,39 |
| AG Cyg | 296 | M | M | −65 | | Op | 3 |
| AM Cyg | 370 | M | Me | −81 | 1.86 | Op | 3 |
| AT Cyg | 264 | M | Me | +36 | | Op | 3,46 |
| AU Cyg | 435 | M | Me | −3 | 1.19 | OH | 16 |
| BG Cyg | 288 | M | Me | −118 | 1.06 | $H_2O$ | 8 |
| BL Cyg | 352 | M | M | +35 | | Op | 3 |
| BU Cyg | 157 | M | M | −28 | 5.87 | Op | 3 |
| CU Cyg | 213 | M | M6e | −87 | | Op | 46 |
| CZ Cyg | 278 | M | | −57 | | Op | 3 |
| DH Cyg | 527 | M | M | −26 | 2.61 | $H_2O$ | 15 |
| DR Cyg | 313 | M | Me | +1 | 2.72 | Op,$H_2O$ | 3,8 |
| DV Cyg | 149 | SR | | −55 | | Op | 3 |
| EH Cyg | 280 | M | Me | +33 | | Op | 3 |
| FF Cyg | 323 | M | Se | +13 | 2.35 | Op | 3 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| FM Cyg | 269 | M | M | −49 | | Op | 3 |
| FP Cyg | 211 | M | | −190 | | Op | 3 |
| HZ Cyg | 180 | M | | −11 | | Op | 3 |
| KM Cyg | 334 | M | M | −24 | | Op | 3 |
| LL Cyg | 211 | M | | −38 | | Op | 3 |
| V369 Cyg | 104 | M | Me | −148 | | $H_2O$ | 67 |
| V378 Cyg | 295 | M | | +45 | | Op | 3 |
| V391 Cyg | 405 | M | M | −40 | 2.76 | OH,$H_2O$ | 15,8 |
| V394 Cyg | 422 | M | | −40 | | Op | 3 |
| V419 Cyg | 226 | M | M | −181 | | Op | 3 |
| V468 Cyg | 485 | M | M | −62 | 2.11 | OH,$H_2O$ | 15,31 |
| V557 Cyg | 382 | M | M | +35 | 2.65 | OH,$H_2O$ | 8,15 |
| $\chi$ Cyg | 408 | M | S/M | −8 | 1.91 | Op,$H_2O$,SiO,CO | 1,6,7,14,24,25,32,36,44,56,57,58 |
| R Del | 285 | M | Me | −48 | 1.93 | Op,$H_2O$,SiO | 1,8,66 |
| S Del | 277 | M | Me | −14 | 2.08 | Op | 1 |
| T Del | 332 | M | Me | −11 | 2.98 | Op | 1 |
| V Del | 533 | M | Me | −30 | 2.74 | Op | 5 |
| X Del | 281 | M | Me | −58 | 2.87 | Op | 5 |
| Z Del | 304 | M | Se | +29 | | Op | 1 |
| RW Del | 237 | M | M | +22 | | Op | 3 |
| SZ Del | 235 | M | Me | −5 | | Op | 3 |
| TV Del | 217 | M | | −152 | | Op | 3 |
| UW Del | 409 | M | M | +11 | | OH,$H_2O$ | 17,19,20,34 |
| WX Del | 526 | M | | +68 | | OH,$H_2O$ | 19,20,34 |
| AG Del | 239 | M | M | −23 | | Op | 3 |
| BB Del | 245 | M | | +47 | | Op | 3 |
| BD Del | 262 | M | Me | −23 | | Op | 3 |
| BR Del | 336 | M | Me | −72 | | Op,OH,$H_2O$ | 3,17,19,20,29,34,43 |
| EP Del | 430 | M | | +53 | | Op | 3 |
| R Dor | 338 | SRb | Me | +21 | 4.03 | Op,$H_2O$,SiO | 1,6,55,70,71 |
| T Dor | 168 | M | Me | −11 | 3.61 | Op | 1 |
| U Dor | 394 | M | Me | +48 | 1.17 | Op,OH,SiO,CO | 1,45,49,50 |
| RX Dor | 335 | M | M7 | +39 | 4.09 | Op | 48 |
| R Dra | 245 | M | Me | −135 | 2.23 | Op,$H_2O$ | 1,8,30 |
| U Dra | 316 | M | Me | −1 | 1.86 | Op,$H_2O$,SiO | 1,8,15,66,67 |
| V Dra | 278 | M | Me | +12 | | Op | 1 |
| W Dra | 278 | M | Me | −22 | | Op | 1 |
| Y Dra | 325 | M | Me | +18 | | Op | 1 |
| RS Dra | 282 | SRa | Me | −30 | 1.96 | Op | 1 |
| RU Dra | 297 | M | MSe | 0 | | Op | 46 |
| SV Dra | 256 | M | Me | +22 | | Op | 1 |
| WZ Dra | 401 | M | Me | −52 | 2.99 | Op | 1 |
| YZ Dra | 347 | M | Me | −1 | 1.96 | OH,$H_2O$ | 15,31 |
| R Equ | 260 | M | Me | −55 | | Op | 1 |
| Z Equ | 211 | M | Me | −105 | | Op | 3 |
| RR Equ | 271 | M | | −48 | | Op | 3 |
| T Eri | 252 | M | Me | +42 | 2.42 | Op | 1 |
| U Eri | 274 | M | Me | −36 | 4.50 | Op | 1 |
| W Eri | 376 | M | Me | +18 | 1.51 | Op,OH,$H_2O$,SiO | 1,30,31,43,55,61 |
| RS Eri | 296 | M | Me | +66 | 1.22 | $H_2O$ | 12 |
| RT Eri | 370 | M | Me | +40 | 0.39 | $H_2O$ | 12 |
| SS Eri | 314 | M | M5 | +48 | 4.35 | Op | 48 |
| SX Eri | 282 | M | | +74 | | Op | 3 |
| TW Eri | 322 | M | M | +55 | 2.62 | Op | 3 |
| WZ Eri | 400 | M | | +23 | | $H_2O$ | 8 |
| BD Eri | 336 | M | Me | +5 | 1.98 | $H_2O$ | 15 |
| EY Eri | 456 | | M8 | +30 | 5.54 | Op,OH | 48 |
| UU For | 480 | | M9 | +6 | 0.98 | CO | 49 |
| R Gem | 369 | M | Se | −44 | 1.78 | Op | 1 |
| S Gem | 293 | M | Me | +106 | 2.96 | Op,OH,$H_2O$,SiO | 1,8,15,30,66,67 |
| T Gem | 287 | M | Se | +18 | 3.54 | Op | 1 |
| V Gem | 274 | M | Me | +19 | 2.81 | Op | 1 |
| X Gem | 264 | M | Me | +37 | 1.86 | Op,OH,SiO | 5,15,32 |
| ST Gem | 246 | M | Me | −57 | | Op | 3 |
| UU Gem | 433 | M | M | +19 | 3.03 | SiO | 41 |
| WZ Gem | 330 | M | Me | +24 | | Op | 3 |
| XX Gem | 384 | M | Me | +46 | 2.00 | $H_2O$ | 15 |
| XY Gem | 341 | M | M | +125 | 3.49 | Op,OH,$H_2O$ | 3,19,20,34 |
| BC Gem | 229 | M | M | +125 | | Op | 3 |
| BR Gem | 155 | M | | +35 | | Op | 3 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| CE Gem | 299 | M | | +68 | | Op | 3 |
| DO Gem | 213 | M | M | −11 | | Op | 3 |
| R Gru | 332 | M | Me | −14 | 1.78 | Op | 1 |
| S Gru | 401 | M | Me | −21 | 0.68 | Op | 1 |
| T Gru | 136 | M | Me | +13 | 5.24 | Op | 1 |
| VW Gru | 260 | M | M8e | +22 | 5.19 | Op | 48 |
| CD Gru | 435 | | M8 | −1 | 3.08 | SiO | 50 |
| CK Gru | 563 | | M9 | −6 | 1.78 | Op,CO | 48,72 |
| R Her | 318 | M | Me | −33 | 3.07 | Op | 1 |
| S Her | 307 | M | Me | −13 | 1.30 | Op | 1 |
| T Her | 165 | M | Me | −124 | 3.22 | Op,SiO | 1,15,66 |
| U Her | 406 | M | Me | −33 | 0.29 | Op,OH,$H_2O$,SiO,CO | 1,6,9,10,13,14,19,20,24,25,27,28,30,31,32,36,40,43,56,57,58 |
| W Her | 280 | M | Me | −52 | 2.90 | Op | 1 |
| RS Her | 219 | M | Me | −43 | 2.92 | Op | 1 |
| RT Her | 298 | M | Me | −70 | | Op,OH | 1,15 |
| RU Her | 484 | M | Me | −29 | 0.36 | Op,OH,SiO,CO | 1,10,14,24,32,43,58 |
| RV Her | 205 | M | Me | −43 | | Op | 1 |
| RY Her | 221 | M | Me | −41 | 4.36 | Op | 1 |
| RZ Her | 329 | M | Me | +33 | | Op | 1 |
| SS Her | 107 | M | Me | −45 | 5.08 | Op | 1 |
| SU Her | 333 | M | Me | −10 | 2.66 | Op | 3 |
| SV Her | 239 | M | Me | −24 | | Op | 1 |
| SY Her | 116 | M | Me | +33 | 4.33 | Op | 5 |
| TV Her | 304 | M | Me | −70 | | Op | 1 |
| UV Her | 342 | M | Me | −5 | 1.78 | Op,OH,$H_2O$,SiO | 1,15,32 |
| VW Her | 284 | M | Me | −1 | | Op | 3 |
| VY Her | 300 | M | Me | −96 | | OH,$H_2O$ | 19,20 |
| WY Her | 376 | M | Me | −17 | 2.65 | OH,$H_2O$ | 8,15,19 |
| WZ Her | 247 | M | | +2 | | Op | 3 |
| XZ Her | 171 | M | M | +33 | 7.02 | Op | 3 |
| AE Her | 249 | M | Me | −52 | | Op | 1 |
| AQ Her | 280 | M | Me | −1 | | Op | 3 |
| AU Her | 399 | M | M8 | −51 | 2.52 | OH,$H_2O$ | 8,19,20,27 |
| BG Her | 347 | M | Me | +12 | 2.53 | $H_2O$ | 15 |
| BK Her | 215 | M | | −56 | | Op | 3 |
| BT Her | 297 | M | | −19 | | Op | 3 |
| CG Her | 180 | M | | −103 | | Op | 3 |
| CZ Her | 322 | M | | +10 | | Op | 3 |
| DE Her | 165 | SRd | K/M | −8 | | Op | 2 |
| DF Her | 337 | M | Me | −54 | 2.52 | Op | 3 |
| DG Her | 293 | M | Me | −80 | | Op | 3 |
| DO Her | 216 | M | | −44 | | Op | 3 |
| DN Her | 226 | M | | −48 | | Op | 3 |
| DR Her | 285 | M | | +14 | | Op | 3 |
| DS Her | 263 | M | | −59 | | Op | 3 |
| DT Her | 300 | M | | −10 | | Op | 3 |
| DU Her | 270 | M | | −42 | | Op | 3 |
| ER Her | 165 | M | | −37 | | Op | 3 |
| EW Her | 228 | M | | −116 | | Op | 3 |
| FI Her | 239 | M | | −187 | | Op | 3 |
| FP Her | 318 | M | M | +40 | | Op | 3 |
| FR Her | 134 | M | M | −125 | | Op | 3 |
| FU Her | 212 | M | | +8 | | Op | 3 |
| FX Her | 354 | M | | +26 | | Op | 3 |
| GI Her | 325 | M | | 0 | | Op | 3 |
| HT Her | 163 | M | | −294 | | Op | 3 |
| KR Her | 135 | M | | −67 | | Op | 3 |
| KT Her | 381 | M | | −42 | | Op | 3 |
| KX Her | 495 | M | Me | −15 | 2.51 | Op | 3 |
| KZ Her | 295 | M | Me | −36 | | Op | 3 |
| LO Her | 471 | M | M | +41 | | Op | 3 |
| LU Her | 217 | M | | −42 | | Op | 3 |
| MV Her | 222 | M | | −24 | | OH,$H_2O$ | 19,20 |
| MW Her | 449 | M | M | −71 | 1.34 | CO | 44 |
| NX Her | 293 | M | | −19 | | Op | 3 |
| V348 Her | 217 | M | | −17 | | Op | 3 |
| V393 Her | 425 | M | | +5 | | $H_2O$ | 8 |
| V697 Her | 475 | | M | +38 | | OH,$H_2O$ | 68,73 |
| R Hor | 407 | M | Me | +50 | 0.93 | Op,OH,SiO,CO | 1,24,49,50,55,74 |
| S Hor | 335 | M | Me | +26 | 3.37 | Op | 1 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| T Hor | 217 | M | Me | +48 | 3.32 | Op | 1 |
| U Hor | 348 | M | Me | −23 | 1.91 | Op | 1 |
| RS Hor | 202 | M | Me | +2 | 4.46 | Op | 1 |
| RT Hor | 335 | M | M5e | +39 | 4.65 | Op | 48 |
| R Hya | 388 | M | Me | −11 | 2.47 | Op,OH,$H_2O$,SiO,CO | 1,10,12,14,24,30,32,53,56,57,58 |
| S Hya | 256 | M | Me | +80 | 2.85 | Op,SiO | 5,15 |
| T Hya | 298 | M | Me | −5 | 2.36 | Op | 1 |
| W Hya | 361 | SRa | Me | +39 | 3.16 | Op,OH,$H_2O$,SiO,CO | 1,6,8,9,10,13,14,18,24,25,30,31,32,36,40,56,58 |
| X Hya | 301 | M | Me | +40 | 0.64 | Op,OH,$H_2O$,SiO,CO | 1,24,30,31,32,43,58 |
| RR Hya | 343 | M | Me | +42 | 2.79 | Op | 1 |
| RT Hya | 290 | SRb | Me | +39 | 0.01 | Op,$H_2O$ | 1,15 |
| RU Hya | 331 | M | Me | −6 | 1.57 | Op,OH,$H_2O$,SiO | 1,30,31,32,43 |
| WW Hya | 310 | M |  | +2 |  | Op | 3 |
| WX Hya | 235 | M | M3 | +116 | 5.00 | Op | 46 |
| IW Hya | 650 |  | M | +54 |  | OH,$H_2O$,SiO | 15,29,62,75 |
| W Hyi | 281 | M | Me | +111 | 6.62 | Op | 48 |
| RS Hyi | 215 | M | Me | +27 | 5.54 | Op | 1 |
| R Ind | 216 | M | Me | +13 | 4.25 | Op | 1 |
| S Ind | 400 | M | Me | +31 | 1.41 | Op,SiO | 1,50 |
| W Ind | 198 | SRc | Me | +62 |  | Op | 1 |
| X Ind | 225 | M | Me | −6 |  | Op | 1 |
| Y Ind | 304 | M | Me | −57 |  | Op | 1 |
| RW Ind | 150 | M | Me | +149 | 5.79 | Op | 1 |
| AP Ind | 400 | M? | M9 | −2 | 2.85 | Op | 48 |
| AV Ind | 304 |  | M9 | −23 | 4.58 | Op | 48 |
| R Lac | 229 | M | Me | +16 |  | Op | 1 |
| S Lac | 241 | M | Me | −62 | 2.50 | Op | 1 |
| SZ Lac | 332 | M | S | −66 |  | Op | 3 |
| AQ Lac | 362 | M | M | −27 |  | Op | 3 |
| AT Lac | 171 | M | M? | −195 | 7.19 | Op | 3 |
| BC Lac | 247 | M | M | −34 |  | Op | 3 |
| DL Lac | 375 | M |  | +12 |  | Op | 3 |
| GV Lac | 467 | M? |  | −38 |  | SiO | 41 |
| R Leo | 310 | M | Me | +9 | 2.55 | Op,OH,$H_2O$,SiO,CO | 1,6,10,13,14,24,25,28,30,32,36,40,43,44,56,57,58 |
| S Leo | 190 | M | Me | +103 | 5.79 | Op | 1 |
| V Leo | 273 | M | Me | −23 | 3.16 | Op,$H_2O$ | 1,30 |
| W Leo | 391 | M | Me | +50 | 2.02 | Op,OH,$H_2O$,SiO | 1,30,43,66 |
| TZ Leo | 331 | M | M | +14 |  | Op | 3 |
| AF Leo | 107 | SRb | M | +7 | 1.37 | OH,$H_2O$ | 15,30 |
| R LMi | 372 | M | Me | +4 | 0.34 | Op,OH,$H_2O$,SiO,CO | 1,10,14,19,20,24,31,32,40,43,44,49,56,58 |
| S LMi | 233 | M | Me | −8 | 3.96 | Op,$H_2O$,SiO | 1,8,66,67 |
| U LMi | 272 | SRa | Me | −25 | 2.87 | Op | 2 |
| T Lep | 368 | M | Me | −10 | 0.09 | Op,$H_2O$,SiO | 1,30,32 |
| X Lep | 278 | M | Me | +63 |  | Op | 3 |
| R Lib | 241 | M | Me | +13 | 5.64 | Op | 1 |
| S Lib | 192 | M | Me | +292 | 4.51 | Op | 1 |
| T Lib | 237 | M | Me | −49 | 5.74 | Op | 1 |
| U Lib | 226 | M | Me | +93 | 4.57 | Op | 1 |
| V Lib | 255 | M | Me | +15 | 4.70 | Op | 1 |
| W Lib | 205 | M |  | +20 |  | Op | 3 |
| X Lib | 164 | M | Me | −34 | 6.47 | Op | 1 |
| Y Lib | 275 | M | Me | −1 | 3.29 | Op,OH,$H_2O$ | 1,30,31,43,54 |
| RR Lib | 277 | M | Me | −34 | 2.47 | Op | 1 |
| RS Lib | 217 | M | Me | +2 | 0.07 | Op,SiO,CO | 5,15,24,32 |
| RT Lib | 251 | M | Me | +41 | 4.31 | Op | 1 |
| RU Lib | 316 | M | Me | −42 | 2.29 | Op | 5 |
| SW Lib | 291 | M | M | −32 | 2.66 | $H_2O$ | 30 |
| UU Lib | 287 | M | Me | −38 |  | Op | 3 |
| EE Lib | 208 | M | Me | −112 |  | Op | 3 |
| EG Lib | 365 | M | M | +5 | 2.79 | OH,$H_2O$ | 12,15 |
| FS Lib | 415 | M | M | −18 | 2.66 | OH,$H_2O$ | 29,30,31,43 |
| R Lup | 235 | M | Me | +8 | 2.96 | Op | 1 |
| S Lup | 339 | M | Se | −45 | 2.89 | Op | 1 |
| Y Lup | 396 | M | Me | −65 | 1.24 | Op | 1 |
| RR Lup | 183 | M | Me | −29 | 2.26 | Op | 1 |
| RX Lup | 237 | M | Me | +13 | 3.08 | Op | 1 |
| R Lyn | 378 | M | Se | +20 | 1.51 | Op | 1 |
| S Lyn | 296 | M | Me | −27 | 3.02 | Op,$H_2O$,SiO | 1,15,59 |
| U Lyn | 433 | M | Me | −12 | 1.41 | Op,OH,$H_2O$,SiO | 1,30,31,32,43 |
| X Lyn | 320 | M | Me | +4 |  | Op | 3 |

**Table A2** – *continued*

| Name | *P* (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| V Lyr | 373 | M | Me | −29 | 2.37 | Op,OH | 1,43 |
| W Lyr | 197 | M | Me | −174 | 3.13 | Op | 5 |
| Z Lyr | 291 | M | Me | +3 | | Op | 1 |
| RS Lyr | 301 | M | Me | −21 | | Op | 1 |
| RT Lyr | 253 | M | Me | −94 | | Op | 1 |
| RU Lyr | 371 | M | Me | −4 | | Op,$H_2O$ | 1,30 |
| RW Lyr | 503 | M | Me | −40 | 2.56 | OH,$H_2O$,SiO | 29,30,31,43,54,76 |
| RX Lyr | 247 | M | Me | −148 | | Op | 3 |
| RY Lyr | 325 | M | Me | −24 | | Op | 1 |
| ST Lyr | 300 | M | Me | −75 | | Op | 46 |
| SV Lyr | 301 | M | M | −5 | | Op | 3 |
| TV Lyr | 262 | M | M4e | −52 | | Op | 46 |
| TX Lyr | 223 | M | Me | −68 | | Op | 3 |
| TY Lyr | 333 | M | Me | −29 | | Op | 3 |
| WZ Lyr | 376 | M | M9e | +5 | | Op | 46 |
| YY Lyr | 136 | M | | −54 | | Op | 3 |
| AC Lyr | 181 | M | M | −7 | | Op | 3 |
| AD Lyr | 190 | M | | −24 | | Op | 3 |
| AS Lyr | 327 | M | | −36 | | Op | 3 |
| BB Lyr | 322 | M | | −42 | | Op | 3 |
| BI Lyr | 249 | M | | +67 | | Op | 3 |
| BL Lyr | 279 | M | | −10 | | Op | 3 |
| BM Lyr | 155 | M | | +20 | | Op | 3 |
| BR Lyr | 215 | M | | −141 | | Op | 3 |
| CK Lyr | 343 | M | | +37 | | Op | 3 |
| DL Lyr | 411 | M | | −4 | | Op | 3 |
| ER Lyr | 196 | M | Me | +39 | 5.20 | Op | 3 |
| FF Lyr | 220 | M | | −103 | | Op | 3 |
| FP Lyr | 278 | M | | −21 | | Op | 3 |
| HI Lyr | 182 | M | Me | −40 | | Op | 3 |
| IS Lyr | 281 | M | | −28 | | Op | 3 |
| IT Lyr | 198 | M | M? | +52 | 7.04 | Op | 3 |
| KZ Lyr | 149 | M | | −16 | | Op | 3 |
| LM Lyr | 326 | M | | −52 | | Op | 3 |
| MP Lyr | 153 | M | M? | −235 | 7.90 | Op | 3 |
| U Men | 407 | SR | Me | +29 | 0.12 | Op,$H_2O$,SiO,CO | 2,47,50,77 |
| RS Men | 304 | M | M8 | +140 | 5.61 | Op | 48 |
| SY Men | 534 | M | M9 | −3 | 3.13 | Op,SiO | 48,50 |
| R Mic | 138 | M | Me | +7 | 3.66 | Op | 1 |
| S Mic | 209 | M | Me | +54 | 4.76 | Op | 5 |
| T Mic | 347 | SRb | Me | +16 | 1.58 | Op,$H_2O$,CO | 2,12,49,50 |
| U Mic | 334 | M | Me | −60 | 1.84 | Op,OH,SiO | 1,29,50 |
| V Mic | 381 | M | Me | −1 | 2.10 | OH | 29 |
| W Mic | 198 | M | Me | −47 | 5.99 | Op | 1 |
| X Mic | 239 | M | Me | +16 | 3.74 | Op | 1 |
| RT Mic | 349 | M | M9 | −60 | 3.93 | Op | 48 |
| RV Mic | 325 | | M6 | −80 | 4.15 | Op | 48 |
| BP Mic | 361 | | M8 | −33 | 3.53 | Op | 48 |
| BQ Mic | 559 | | M9 | −28 | 2.22 | CO | 49 |
| V Mon | 340 | M | Me | +20 | 1.09 | Op,SiO | 5,15,32,56 |
| X Mon | 155 | SRb | Me | +159 | 2.87 | Op | 1 |
| Y Mon | 227 | M | Me | +65 | 3.77 | Op | 5 |
| RR Mon | 394 | M | Se | +23 | 2.36 | Op | 1 |
| RS Mon | 263 | M | Me | −9 | | Op | 3 |
| SY Mon | 422 | M | Me | −40 | 1.51 | OH,$H_2O$,SiO | 8,43,61 |
| TT Mon | 323 | M | Me | +59 | 2.03 | Op,$H_2O$ | 3,30 |
| AG Mon | 155 | M | M? | +55 | 6.05 | Op | 3 |
| AH Mon | 374 | M | M | +131 | | Op | 3 |
| AL Mon | 243 | M | M | +90 | | Op | 3 |
| AM Mon | 432 | M | M | +15 | 2.90 | Op | 3 |
| BC Mon | 272 | M | Me | −11 | | Op | 3 |
| BD Mon | 373 | M | Se | +54 | | Op | 3 |
| BL Mon | 144 | M | | +47 | | Op | 3 |
| CM Mon | 150 | M | | +25 | | Op | 3 |
| CN Mon | 373 | M | M | +61 | 4.83 | Op | 3 |
| FX Mon | 428 | M | M | +48 | 2.58 | OH,$H_2O$ | 12,16,43 |
| GX Mon | 527 | M | M | +8 | 1.07 | Op,OH,$H_2O$,SiO,CO | 3,10,19,20,29,34,43,44,58 |
| HN Mon | 410 | M | M | +95 | 3.40 | SiO | 15,41 |
| QQ Mon | 222 | M | M | +89 | | Op | 3 |
| R Nor | 507 | M | Me | −28 | 1.27 | Op | 1 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| T Nor | 240 | M | Me | −33 | 2.16 | Op | 1 |
| R Oct | 405 | M | Me | +36 | 0.75 | Op,SiO | 1,50 |
| S Oct | 259 | M | Me | −55 | | Op | 1 |
| T Oct | 218 | M | Me | +80 | | Op | 1 |
| U Oct | 308 | M | Me | +34 | 2.25 | Op | 1 |
| X Oct | 206 | SRa | Me | −2 | 1.73 | Op | 2 |
| RR Oct | 273 | M | M5 | −41 | 4.04 | Op | 48 |
| TW Oct | 132 | SR | Me | +114 | 3.44 | Op | 2 |
| UX Oct | 303 | M? | M8e | +3 | 4.46 | Op | 48 |
| CM Oct | 473 | | M6 | −5 | 4.87 | Op,OH | 48 |
| R Oph | 306 | M | Me | −49 | 0.94 | Op,SiO | 15,28,32,56 |
| S Oph | 233 | M | Me | −11 | 3.77 | Op,$H_2O$ | 1,67 |
| T Oph | 366 | M | Me | −46 | 1.54 | Op,OH,SiO | 1,15,32,56 |
| W Oph | 332 | M | Me | −46 | 2.65 | Op | 1 |
| X Oph | 328 | M | Me | −75 | 0.98 | Op,OH,$H_2O$,SiO,CO | 5,24,30,32,43,61 |
| Z Oph | 348 | M | KMe | −83 | 4.01 | Op | 1 |
| RR Oph | 292 | M | Me | +57 | 2.62 | Op | 1 |
| RT Oph | 426 | M | Me | −39 | 1.84 | Op,OH,$H_2O$,SiO | 1,30,43,61 |
| RU Oph | 202 | M | Me | −67 | 4.37 | Op | 1 |
| RX Oph | 322 | M | M | −65 | 2.66 | OH,$H_2O$ | 19,20,30,31,34,43 |
| RY Oph | 150 | M | Me | −62 | 2.95 | Op,SiO | 5,15 |
| SS Oph | 180 | M | Me | −34 | 2.63 | Op | 5 |
| UY Oph | 332 | M | M | −82 | 2.80 | OH,$H_2O$ | 15 |
| VW Oph | 285 | M | Me | −93 | 4.79 | Op | 3 |
| XY Oph | 362 | M | | −86 | | OH,$H_2O$ | 19,20,27 |
| AH Oph | 353 | M | M | +36 | 2.47 | $H_2O$ | 30 |
| BC Oph | 307 | M | Me | +25 | 2.45 | Op | 3,46 |
| DO Oph | 234 | M | | −93 | | Op | 3 |
| DP Oph | 213 | M | | −143 | | Op | 3 |
| KT Oph | 216 | M | | −21 | | Op | 3 |
| KU Oph | 382 | M | Me | +38 | 4.00 | Op | 3 |
| V379 Oph | 221 | M | | +32 | | Op | 3 |
| V389 Oph | 315 | M | | +8 | | Op | 3 |
| V438 Oph | 169 | SRa | Me | −10 | 0.65 | $H_2O$ | 30 |
| V457 Oph | 190 | M | | +144 | | Op | 3 |
| V578 Oph | 180 | M | | −6 | | Op | 3 |
| V584 Oph | 276 | M | | +32 | | Op | 3 |
| V588 Oph | 191 | M | | −21 | | Op | 3 |
| V603 Oph | 345 | M | | +90 | | OH,$H_2O$ | 19,20 |
| V640 Oph | 226 | M | | +36 | | OH,$H_2O$ | 19,20,34 |
| V653 Oph | 276 | M | | −2 | | Op | 3 |
| V665 Oph | 503 | M | | +53 | | OH,$H_2O$ | 17,19,20,34 |
| V790 Oph | 370 | M | Me | −76 | | OH,$H_2O$ | 8,16 |
| V850 Oph | 345 | M | M | −6 | 2.66 | OH,$H_2O$ | 8,15 |
| V884 Oph | 210 | M | | +14 | | Op | 3 |
| V885 Oph | 350 | M | Me | +133 | | Op | 3 |
| V915 Oph | 111 | M | Me | −31 | | Op | 3 |
| V970 Oph | 275 | M | | +32 | | OH,$H_2O$ | 19,20 |
| S Ori | 414 | M | Me | +24 | 0.07 | Op,OH,SiO,CO | 1,24,32,43,58 |
| U Ori | 368 | M | Me | −25 | 0.75 | Op,OH,$H_2O$,SiO,CO | 1,6,8,10,13,24,28,29,30,31,32,43,58 |
| V Ori | 263 | M | Me | +21 | 3.99 | Op | 1 |
| Y Ori | 271 | M | Me | +61 | 2.36 | Op | 3 |
| RR Ori | 251 | M | Me | −33 | 3.04 | Op | 3 |
| BK Ori | 354 | M | Me | +13 | 2.05 | Op,SiO | 3,61 |
| CL Ori | 215 | M | Me | −12 | | Op | 3 |
| EK Ori | 148 | M | | −9 | | Op | 3 |
| EU Ori | 327 | M | M | +69 | | Op | 3 |
| GV Ori | 313 | M | | +44 | | Op | 3 |
| V382 Ori | 225 | M | M | +10 | | Op | 3 |
| R Pav | 229 | M | Me | +36 | 2.89 | Op | 1 |
| S Pav | 380 | SRa | Me | −21 | 1.38 | Op,SiO | 1,50 |
| T Pav | 243 | M | Me | +66 | 2.87 | Op | 1 |
| W Pav | 283 | M | Me | +63 | | Op | 1 |
| SU Pav | 245 | M | Me | +16 | | Op | 1 |
| SY Pav | 193 | M | Me | +101 | 6.35 | Op | 1 |
| DM Pav | 287 | M | M8 | −4 | 5.97 | Op | 48 |
| V350 Pav | 479 | M | M9 | +2 | 2.30 | CO | 49,72 |
| V351 Pav | 486 | | M8 | −29 | 2.61 | Op,OH | 48 |
| R Peg | 378 | M | Me | +17 | 0.51 | Op,OH,$H_2O$,SiO,CO | 1,24,30,32,43,58 |
| S Peg | 319 | M | Me | +2 | 1.41 | Op,SiO | 5,32 |

**Table A2** – *continued*

| Name | *P* (d) | Var | Sp | RV (km s$^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| T Peg | 379 | M | Me | −14 | 1.89 | Op | 1 |
| V Peg | 302 | M | Me | −30 | 3.25 | Op,SiO | 1,15 |
| W Peg | 345 | M | Me | −24 | 0.02 | Op,OH,$H_2O$,SiO,CO | 5,15,24,30,32,56,58 |
| X Peg | 201 | M | Me | −59 | 4.47 | Op | 1 |
| Y Peg | 206 | M | Me | −88 | 5.69 | Op | 1 |
| Z Peg | 334 | M | Me | −35 | 1.09 | Op,SiO | 1,32 |
| RR Peg | 264 | M | Me | −30 | | Op | 1 |
| RS Peg | 415 | M | Me | −31 | 1.20 | Op,OH,SiO | 1,43,61 |
| RT Peg | 215 | M | Me | −118 | | Op | 1 |
| RV Peg | 396 | M | Me | −35 | 2.17 | Op,OH,SiO | 1,43,56 |
| RW Peg | 208 | M | KMe | −79 | 4.78 | Op | 1 |
| SS Peg | 424 | M | Me | −22 | 1.11 | Op,SiO | 1,61 |
| TU Peg | 321 | M | Me | −2 | 1.10 | OH,$H_2O$,SiO | 15,32,61,67 |
| TZ Peg | 211 | M | Me | −15 | | Op | 3 |
| UU Peg | 456 | M | Me | +15 | 1.32 | OH,$H_2O$,CO | 30,43,44 |
| VY Peg | 377 | M | M7 | +24 | 4.20 | Op | 3 |
| AK Peg | 193 | SRa | Me | −6 | 2.96 | Op | 2 |
| AP Peg | 300 | M | Me | +38 | | Op | 3 |
| DG Peg | 146 | M | Me | −120 | | Op | 3 |
| DL Peg | 180 | M | M | −35 | 6.72 | Op | 3 |
| KZ Peg | 452 | | M9 | −7 | 1.58 | Op,OH | 29,48 |
| LV Peg | 166 | | M8 | −59 | 5.19 | Op | 48 |
| MP Peg | 316 | | M5 | −115 | 5.24 | Op,OH | 48,51 |
| MR Peg | 391 | | M9 | −55 | 4.95 | Op,OH | 19,48 |
| MV Peg | 282 | | M8e | −94 | 5.15 | Op | 48 |
| R Per | 209 | M | Me | −82 | | Op | 1 |
| U Per | 320 | M | Me | +14 | 0.92 | Op | 1 |
| RR Per | 389 | M | Me | +3 | 1.50 | Op,OH,SiO | 1,32,43,53 |
| RU Per | 170 | SR? | Me | −40 | 1.94 | Op | 2 |
| RZ Per | 355 | M | Se | −17 | | Op | 1 |
| AL Per | 145 | M | | −226 | | Op | 3 |
| AM Per | 250 | M | M | −6 | 2.94 | Op | 3 |
| FG Per | 340 | M | | −33 | | Op | 3 |
| FI Per | 427 | M | M | −58 | | SiO | 41 |
| GG Per | 277 | M | | −57 | | Op | 3 |
| R Phe | 269 | M | Me | +10 | 3.21 | Op | 1 |
| S Phe | 141 | SR | Me | +3 | 1.58 | Op | 1 |
| W Phe | 334 | M | Me | +53 | 2.66 | Op | 1 |
| RU Phe | 286 | M | M1e | +17 | 4.00 | Op | 48 |
| BE Phe | 0 | | | −87 | | $H_2O$ | 12 |
| R Pic | 170 | SRa | Me | +207 | 3.45 | Op | 1 |
| S Pic | 428 | M | Me | +19 | 0.72 | Op,OH,SiO,CO | 1,24,49,50 |
| T Pic | 200 | M | Me | +43 | 4.26 | Op | 1 |
| UX Pic | 386 | | M8 | +24 | 3.06 | Op,OH | 45,48 |
| R Psc | 344 | M | Me | −52 | 2.11 | Op,OH,SiO | 5,16,32 |
| S Psc | 404 | M | Me | +10 | 2.39 | Op | 5 |
| U Psc | 173 | M | Me | −36 | 6.58 | Op | 3 |
| X Psc | 349 | M | Me | +6 | 2.69 | Op | 1 |
| RR Psc | 270 | M | M? | −128 | 6.04 | Op | 3 |
| WX Psc | 644 | | M8 | +11 | 2.49 | OH,$H_2O$,SiO,CO | 17,19,20,29,32,44,58 |
| AW Psc | 545 | | M9 | −26 | 2.33 | CO | 49 |
| R PsA | 297 | M | Me | −28 | 3.60 | Op | 1 |
| S PsA | 271 | M | Me | −95 | 3.65 | Op | 1 |
| RX PsA | 366 | SRa | Me | −38 | 5.18 | Op | 2 |
| SY PsA | 335 | M | M8e | −42 | 4.02 | Op | 48 |
| U Pup | 318 | M | Me | −2 | 1.46 | Op,OH | 1,29,43,53 |
| W Pup | 119 | M | Me | +16 | 3.55 | Op | 1 |
| Z Pup | 508 | M | Me | +20 | 1.33 | Op,OH,$H_2O$,SiO | 1,30,31,32,43,58 |
| RV Pup | 188 | M | Me | +91 | 3.63 | Op | 1 |
| RW Pup | 340 | M | Me | +59 | 2.99 | Op | 1 |
| SS Pup | 391 | M | Me | +101 | 2.70 | OH | 29,43 |
| SV Pup | 166 | M | Me | +46 | 3.59 | $H_2O$ | 8 |
| TZ Pup | 317 | M | M | +70 | | Op | 3 |
| UU Pup | 282 | M | M | +79 | 4.50 | Op | 3 |
| UW Pup | 422 | M | M9 | +101 | | Op | 3 |
| AS Pup | 324 | M | Me | −24 | 0.27 | Op | 1 |
| CH Pup | 505 | M | Me | +30 | 1.51 | OH,SiO | 15 |
| FO Pup | 318 | M | Me | +87 | | Op | 3 |
| $L_2$ Pup | 140 | SRb | Me | +53 | 2.24 | Op,OH,$H_2O$,SiO,CO | 1,47,50,55,60,70,71,80 |
| S Pyx | 206 | M | Me | +97 | 4.04 | Op | 1 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| R Ret | 278 | M | Me | +20 | 1.74 | Op | 1 |
| W Sge | 278 | M | Me | −67 | 2.93 | Op | 1 |
| Y Sge | 146 | M | M | +2 | | Op | 3 |
| RT Sge | 299 | M | | +21 | | Op | 3 |
| RW Sge | 444 | M | M | −119 | | Op | 3 |
| RX Sge | 439 | M | M | +8 | | Op,OH,$H_2O$ | 3,16,19,20,34 |
| TX Sge | 156 | M | | 0 | | Op | 3 |
| BM Sge | 312 | M | | 0 | 3.55 | Op | 3 |
| CS Sge | 351 | M | | +32 | | Op | 3 |
| R Sgr | 269 | M | Me | −45 | 2.06 | Op | 1 |
| S Sgr | 230 | M | M | +33 | 4.68 | Op | 1 |
| T Sgr | 394 | M | Se | −2 | 1.29 | Op | 5 |
| Z Sgr | 450 | M | Me | −26 | 1.95 | Op | 1 |
| RR Sgr | 336 | M | Me | +83 | 0.69 | Op,OH,$H_2O$,SiO | 1,30,43,61 |
| RT Sgr | 306 | M | Me | +32 | 1.33 | Op | 1 |
| RU Sgr | 240 | M | Me | −68 | 2.18 | Op | 1 |
| RV Sgr | 315 | M | Me | +20 | 1.63 | Op | 1 |
| RW Sgr | 186 | SRa | Me | −52 | 3.06 | Op | 1 |
| RX Sgr | 335 | M | Me | −28 | 2.88 | Op | 1 |
| ST Sgr | 395 | M | Se | +40 | 1.38 | Op,SiO | 1,14 |
| TV Sgr | 266 | M | Me | +27 | | Op | 1 |
| UU Sgr | 267 | M | Me | +11 | 1.50 | Op | 1 |
| VV Sgr | 401 | M | Me | +44 | 1.75 | OH,$H_2O$ | 29,30,43 |
| AL Sgr | 78 | M | M? | −7 | 5.85 | Op | 3 |
| BM Sgr | 402 | M | Me | +79 | | Op | 1 |
| BU Sgr | 313 | M | Me | +20 | | Op | 3 |
| FQ Sgr | 434 | M? | Me | −6 | 1.57 | OH,$H_2O$,SiO | 15,77 |
| V342 Sgr | 372 | M | M | +30 | 1.34 | SiO,CO | 15,49 |
| V2059 Sgr | 405 | M | M | +46 | 1.68 | OH,SiO | 15 |
| V2234 Sgr | 464 | SR? | M9e | −43 | 1.37 | Op,CO | 48,49 |
| V3880 Sgr | 510 | | M | +6 | 2.31 | OH,$H_2O$,SiO | 29,80,83 |
| R Sco | 224 | M | Me | −3 | 5.15 | Op | 1 |
| S Sco | 177 | M | Me | +84 | 5.08 | Op | 1 |
| W Sco | 221 | M | | +21 | | Op | 3 |
| X Sco | 199 | M | Me | −50 | 5.84 | Op | 3,46 |
| Z Sco | 343 | M | Me | −57 | 1.48 | Op | 1 |
| RR Sco | 281 | M | Me | −39 | 0.23 | Op,SiO,CO | 1,15,24,32 |
| RS Sco | 319 | M | Me | +2 | 0.40 | Op,CO | 1,24 |
| RT Sco | 449 | M | Me | −58 | 0.41 | Op | 1 |
| RU Sco | 370 | M | Me | +29 | 0.96 | Op | 1 |
| RW Sco | 389 | M | Me | −79 | 1.30 | Op,OH,$H_2O$,SiO | 1,29,32,43,55,65 |
| RZ Sco | 156 | M | Me | −175 | 4.19 | Op,$H_2O$ | 1,67 |
| SW Sco | 260 | M | Me | −74 | | Op | 1 |
| SY Sco | 234 | M | Me | −20 | | Op,OH | 1,43 |
| TU Sco | 373 | M | Me | −16 | 2.75 | Op,OH | 1,43 |
| WW Sco | 431 | M | Me | +11 | 2.09 | Op | 1 |
| KS Sco | 429 | M | Me | −130 | | Op | 1 |
| S Scl | 362 | M | Me | +23 | 0.31 | Op,SiO | 1,15,32,50 |
| U Scl | 335 | M | M8 | −8 | 3.80 | Op | 48 |
| V Scl | 296 | M | Me | +44 | 3.13 | Op | 3 |
| SW Scl | 146 | SR | Me | +32 | 3.72 | Op | 1 |
| SY Scl | 415 | M | M6e | +24 | 2.61 | Op,OH,$H_2O$ | 15,31,48 |
| V Sct | 252 | M | Me | +30 | | Op | 3 |
| ST Sct | 219 | M | Me | +46 | | Op | 3 |
| R Ser | 356 | M | Me | +15 | 0.82 | Op,$H_2O$,CO,SiO | 1,24,28,30,32,57,58 |
| S Ser | 371 | M | Me | +8 | 1.76 | Op,OH,$H_2O$,SiO | 1,28,30,31,32,43,58 |
| T Ser | 338 | M | Me | 0 | 2.53 | Op | 1 |
| U Ser | 237 | M | Me | −32 | 3.53 | Op | 1 |
| RU Ser | 280 | M | | +8 | | Op | 3 |
| RV Ser | 269 | M | Me | −14 | 3.22 | OH,$H_2O$ | 15 |
| WW Ser | 365 | M | Me | +6 | 1.76 | Op,$H_2O$ | 3,30 |
| WX Ser | 425 | M | Me | −9 | 2.46 | OH,$H_2O$,SiO,CO | 29,30,31,32,43,44,58 |
| BC Ser | 245 | M | Me | +54 | | Op | 3,46 |
| BG Ser | 143 | M | Me | −16 | 0.39 | $H_2O$,SiO | 12,15 |
| CU Ser | 263 | M | | −77 | | Op | 3 |
| CY Ser | 289 | M | Me | +7 | 3.06 | Op | 3 |
| S Sex | 264 | M | Me | −3 | 3.41 | Op | 5 |
| R Tau | 320 | M | Me | +28 | 0.82 | Op,OH,$H_2O$,SiO | 1,30,31,32,43,58 |
| S Tau | 374 | M | Me | +34 | 3.09 | Op,OH,SiO | 1,15,66 |
| V Tau | 168 | M | Me | +69 | 4.10 | Op | 5 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| Z Tau | 466 | M | SeM | 0 | 3.36 | Op | 3 |
| RX Tau | 331 | M | Me | −31 | 1.21 | Op,OH,$H_2O$,SiO | 1,30,61,84 |
| VX Tau | 298 | M | Me | +37 | | Op | 3 |
| AG Tau | 206 | M | | +21 | | Op | 3 |
| AW Tau | 654 | M | M | +1 | 3.06 | OH,$H_2O$,SiO | 29,30,31,41 |
| IK Tau | 470 | M | Me | +46 | 0.69 | OH,$H_2O$,SiO,CO,SO | 10,14,19,20,29,30,31,32,33,34,36,40,44,49,58 |
| V1083 Tau | 342 | | M9 | +82 | 5.03 | Op | 48 |
| R Tel | 461 | M | Me | +8 | | Op | 1 |
| U Tel | 445 | M | Me | −54 | 1.39 | Op,SiO | 1,50 |
| W Tel | 303 | M | Me | −18 | | Op | 1 |
| X Tel | 309 | M | M5e | −65 | 4.58 | Op | 48 |
| SS Tel | 415 | M | SiO | +3 | 0.66 | SiO | 50 |
| TY Tel | 361 | M | SiO | −51 | 2.99 | SiO | 50 |
| BH Tel | 210 | M | Me | +22 | | Op | 1 |
| BQ Tel | 290 | M | Me | +10 | 3.43 | Op | 1 |
| GX Tel | 345 | M | M8e | +57 | 4.76 | Op | 48 |
| R Tri | 266 | M | Me | +63 | 0.97 | Op,$H_2O$,SiO | 1,30,61 |
| T Tri | 324 | M | Me | −113 | | Op | 3 |
| Z TrA | 150 | M | Me | −27 | 3.53 | Op | 1 |
| S Tuc | 240 | M | Me | −22 | 4.57 | Op | 1 |
| T Tuc | 250 | M | Me | −48 | 3.22 | Op | 1 |
| U Tuc | 264 | M | Me | −23 | 2.95 | Op | 1 |
| TZ Tuc | 239 | M | Me | +195 | | Op | 1 |
| UU Tuc | 327 | M | M4e | +28 | 3.53 | Op | 48 |
| R UMa | 301 | M | Me | +31 | 1.37 | Op,$H_2O$,SiO | 1,8,28,30,32 |
| S UMa | 225 | M | Se | +6 | 3.04 | Op | 1 |
| T UMa | 256 | M | Me | −97 | 2.94 | Op,$H_2O$,SiO | 1,28,30,57,66 |
| X UMa | 249 | M | Me | −83 | | Op | 1 |
| Z UMa | 195 | SRb | Me | −55 | 0.89 | Op | 1 |
| RR UMa | 230 | M | Me | −41 | | Op | 1 |
| RS UMa | 258 | M | Me | −28 | | Op,$H_2O$ | 1,30 |
| RU Uma | 252 | M | Me | −61 | | Op | 5 |
| VX UMa | 215 | M | Me | −58 | 2.70 | OH,$H_2O$ | 15,30,31 |
| R UMi | 325 | SRa | Me | −23 | 0.19 | $H_2O$,SiO | 30,61 |
| S UMi | 331 | M | Me | −49 | 0.20 | Op,SiO | 1,32,56 |
| T UMi | 301 | M | Me | −9 | 2.58 | Op,$H_2O$ | 1,30 |
| U UMi | 330 | M | Me | −27 | 0.84 | Op,OH,SiO | 1,32,43 |
| W Vel | 394 | M | Me | +4 | 0.56 | Op,OH,SiO | 1,50,85 |
| Y Vel | 449 | M | Me | −1 | 1.19 | Op | 1 |
| Z Vel | 411 | M | Me | +7 | 0.89 | Op | 1 |
| RS Vel | 409 | M | Me | +5 | 0.06 | Op | 1 |
| RT Vel | 141 | M? | Me | −25 | | Op | 1 |
| RU Vel | 125 | SR? | Me | −5 | | Op | 1 |
| RW Vel | 443 | M | Me | +5 | 0.41 | Op,SiO | 1,50 |
| WX Vel | 411 | M | Me | +31 | 1.81 | Op | 1 |
| CI Vel | 142 | M | Me | +29 | 6.38 | Op | 1 |
| R Vir | 145 | M | Me | −28 | 2.05 | Op,OH,SiO | 1,15,28,57 |
| S Vir | 375 | M | Me | +5 | 0.33 | Op,$H_2O$,SiO,CO | 1,24,28,30,32,65 |
| T Vir | 339 | M | Me | +10 | 3.23 | Op,OH,$H_2O$,SiO | 1,29,30,31,43,66 |
| U Vir | 206 | M | Me | −48 | 4.01 | Op | 1 |
| V Vir | 250 | M | Me | +33 | 3.89 | Op | 1 |
| Y Vir | 218 | M | Me | +7 | 4.70 | Op | 1 |
| Z Vir | 305 | M | Me | +66 | 4.71 | Op | 1 |
| RR Vir | 217 | M | M? | −45 | 7.16 | Op | 3 |
| RS Vir | 354 | M | Me | −24 | 1.11 | Op,OH,$H_2O$,SiO | 1,28,29,30,31,32,43,58 |
| RV Vir | 265 | M | Me | +32 | 5.14 | Op | 1 |
| SU Vir | 208 | M | Me | +19 | 5.07 | Op | 1 |
| SV Vir | 295 | M | Me | 0 | 3.07 | $H_2O$ | 30 |
| AQ Vir | 292 | M | Me | −7 | | Op | 3 |
| BZ Vir | 150 | M | M5e | +2 | 5.34 | Op | 46 |
| T Vol | 175 | M | Me | −15 | 3.73 | Op | 1 |
| R Vul | 136 | M | Me | −14 | 3.24 | Op | 1 |
| RU Vul | 173 | SRa | Me | −88 | | Op | 1 |
| RW Vul | 208 | M | M | −33 | | Op | 3 |
| RX Vul | 457 | M | Me | +12 | 1.06 | Op | 3,46 |
| SZ Vul | 253 | M | | −99 | | Op | 3 |
| XY Vul | 288 | M | Me | −12 | | Op | 3 |
| YZ Vul | 376 | M | M5e | −8 | 2.78 | Op | 46 |
| BY Vul | 305 | M | | +26 | | Op | 3 |
| CI Vul | 317 | M | | −24 | | Op | 3 |

**Table A2** – *continued*

| Name | $P$ (d) | Var | Sp | RV ($km\,s^{-1}$) | $\bar{K}$ (mag) | Method | References |
|---|---|---|---|---|---|---|---|
| CN Vul | 330 | M | Me | +7 | | OH | 19 |
| DE Vul | 298 | M | M | +11 | | Op | 3 |

*Notes to Table A2*: (1) Feast (1963). (2) Feast et al. (1972). (3) Smak & Preston (1965). (4) –. (5) Kennan, Garrison & Deutsch (1974). (6) Wallerstein (1975). (7) Wallerstein & Fawley (1980). (8) Benson & Little-Marenin (1996). (9) Imai et al. (1997). (10) Cernicharo et al. (1997). (11) –. (12) Lewis (1997a). (13) Yates & Cohen (1996). (14) Bujarrabal et al. (1996). (15) Lewis, David & Le Squeren (1995). (16) Lewis (1994). (17) Brand et al. (1994). (18) Szymczak et al. (1995). (19) Lewis (1997b). (20) Engels & Lewis (1996). (21) –. (22) –. (23) –. (24) Young (1995). (25) Menten & Young (1995). (26) David et al. (1993). (27) Chengalur et al. (1993). (28) Barbier et al. (1988). (29) te Lintel Hekkert et al. (1989). (30) Cesaroni et al. (1988). (31) Comoretto et al. (1990). (32) Cho, Kaifu & Ukita (1996). (33) Sahai & Wannier (1992). (34) Lewis, Eder & Terzian (1990). (35) Sivagnanam et al. (1990). (36) Alcolea & Bujarrabal (1992). (37) Le Squeren et al. (1992). (38) Le Bertre & Nyman (1990). (39) Wallerstein & Dominy (1988). (40) Alcolea, Bujarrabal & Gallego (1989). (41) Jiang et al. (1996). (42) Dominy, Wallerstein & Suntzeff (1985). (43) Sivagnanam et al. (1989). (44) Margulis et al. (1990). (45) te Lintel Hekkert et al. (1991). (46) Perry & Bidelman (1965). (47) Kerschbaum, Olofsson & Hron (1996). (48) Whitelock et al. (1994). (49) Nyman et al. (1992). (50) Haikala (1990). (51) Eder, Lewis & Terzian (1988). (52) –. (53) Slootmaker, Herman & Habing (1985). (54) Ukita & Le Squeren (1984). (55) Lepine, Le Squeren & Scalise (1978). (56) Barcia et al. (1985). (57) Heske (1989). (58) Spencer et al. (1981). (59) Benson & Little-Marenin (1989). (60) Dickinson et al. (1986). (61) Bujarrabal, Planesas & del Romero (1987). (62) Kleinmann, Dickinson & Sargent (1978). (63) Engels, Schmid-Burgk & Walmsley (1988). (64) Bowers & Hagen (1984). (65) Lepine, Le Squeren & Scalise (1979). (66) Jewell et al. (1985). (67) Little-Marenin & Benson (1988). (68) Lewis & Engels (1988). (69) –. (70) Lepine, Paes de Barros & Gammon (1976). (71) Knowles & Batchelor (1978). (72) Deguchi, Nakada & Sahai (1990). (73) Silverglate et al. (1979). (74) Robinson, Caswell & Goss (1971). (75) Crocker & Hagen (1983). (76) Nyman, Johansson & Booth (1986). (77) Deguchi, Nakada & Forster (1989). (78) –. (79) –. (80) Balister et al. (1977). (81) –. (82) –. (83) Dickinson (1976). (84) Bowers & Sinha (1978). (85) Bowers & Kerr (1977).

uncertainties, there is no significant difference between the velocities derived from $H_2O$, SiO or CO, and those derived from OH, and no zero-point correction has been applied to these results. The optical velocities, however, are systematically more positive by $3.9 \pm 0.7\,km\,s^{-1}$ than the OH ones. This is in the same sense as previously reported (Reid 1976; Barbier et al. 1988) and no doubt results from the complex dynamics of Mira atmospheres. There is some slight evidence in Fig. A1 of a dependence of the OH−optical difference on period. A linear fit of this difference gives

$$\mathrm{OH} - \mathrm{optical} = -0.015P + 1.31 \qquad \text{(A1)}$$

All the optical radial velocities used here have been corrected to the OH zero-point, using this equation. There was a suggestion in the earlier data (Reid 1976) that the OH – optical difference might not be the same for the subsample of Miras for which absorption-line velocities were measured and that for which the effective absorption velocity was derived (as described above) from measurements of emission lines. In the present (enlarged) sample, any such effect is negligibly small. We find

(i) for 32 stars with directly measured absorption velocities and OH maser lines, a mean difference from equation (A1) of

$-1.0 \pm 0.8(\sigma = 4.4)\,km\,s^{-1}$

(ii) for 45 stars with effective absorption velocities inferred from emission lines and with measured OH maser lines, a mean difference from equation (A1) of

$+0.7 \pm 1.1(\sigma = 7.4)\,km\,s^{-1}$.

The difference between these two samples is not significant ($1.7 \pm 1.4\,km\,s^{-1}$) and no correction for this has been applied. The standard deviations ($\sigma$) of these two samples, together with those shown in Table A1, give some indication of the uncertainty attached to the radial velocities.

In compiling these data, two groups of objects have been specifically omitted. The first group consists of Miras (and OH/IR variables) in the Galactic bulge itself. The second group consists of very long-period Miras with thick circumstellar shells and long-period OH/IR variables with thick shells. Whilst such stars are of great interest, their distances are difficult to estimate, at least using *K*-band photometry and a PL relation. They are therefore not relevant to the main topic of the present paper. This means that the catalogue does not claim completeness for Mira-like variables (including OH/IR stars) of periods greater than ~500 d.

With some minor exceptions, the optical radial velocities are published in a heliocentric system. Radio astronomers generally publish their velocities corrected for local Solar motion. Unfortunately, they rarely state what they have assumed the local Solar motion to be. However, it would appear that almost always they adopt a Solar motion of $20\,km\,s^{-1}$ towards $\alpha = 18^h$ and $\delta = +30°$ (1900) (see, for instance, Kerr 1962; Lindblad 1966). We have therefore re-reduced all the radio data (and a small number of optical observations) to heliocentric using these values. The radial velocities marked '$V_{other}$' in table 5 of Whitelock et al. (1994) were erroneously corrected to heliocentric. Corrected values were used in the present paper. Sometimes identical (radio) velocities are given in two, or more, places. It is usually clear from the context whether these are independent measurements or not. In general, when the radial velocity of a star has been determined in a number of different ways (optical, OH, etc.), straight means have been taken of the various estimates (after correcting the optical values to the OH zero-point, as described above). However, in some cases, observations that seem rather uncertain have been rejected. This includes a very small number of cases when the results from different methods were strongly discrepant. Table A2 lists the results. It also contains the following information, mostly from the General Catalogue of Variable Stars: the pulsation period ($P$), the type of variability (Var) and the spectral type (Sp). The $K$ magnitude that is listed in column 6 ($\bar{K}$) is taken from SAAO data (Paper I and unpublished) where possible, but otherwise from Gezari, Pitts & Schmitz (1997). It is the mean of the maximum and minimum values recorded.

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