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RADIAL VELOCITIES AND ORBITAL SOLUTION OF THE ACTIVE BINARY STAR FG URSAE MAJORIS

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FG Ursae Majoris (HD 89546) is an active single-lined binary, whose spectral type is approximately G8 IV (Henry et al. 1995). Although its relatively high luminosity ($V = 7^{\rm m}\!.4$, amplitude of the variability = 0.04−0.15 mag, Henry et al. 1995), FG UMa is a poorly studied binary. Together with photospheric variability, the star shows typical signatures of strong chromospheric activity. Montes et al. (2000) reported on filled-in Hα and Hβ lines and strong Ca II H & K emission with self-absorption. Similar features were found by Strassmeier et al. (2000). Hα variability is reported in the CABS (Strassmeier et al. 1993) and by Henry et al. (1995). No radial velocity and orbital solution of FG UMa has been published till now.

Spectroscopic observations were obtained at *M. G. Fracastoro* station of Catania Astrophysical Observatory in 1997, 1999 and 2000 with the 91-cm telescope, using the REOSC echelle spectrograph in the cross-dispersion configuration. This mode yields a resolution of $\lambda/\Delta\lambda \simeq 14000$. The spectrograph is fed by the telescope through an optical fiber (UV-NIR, 200μm core diameter) and is placed in a stable position on the first floor of the telescope building. The detector used during the 1997 observations was an 800×1152 CCD with a pixel size of 22.4 μm. For the 1999 and 2000 observations a back-illuminated 1024×1024 CCD, with a pixel size of 24 μm, was used. Signal-to-noise ratio from 100 to 250, depending on atmospheric conditions, was reached.

Data reduction was performed using the ECHELLE task of the IRAF package. The data were bias-subtracted and then flat-field corrected using halogen lamp spectra. The wavelength calibration is based on a thorium-argon comparison lamp.

Radial velocities were obtained by cross-correlation of each order of FG UMa spectra with the corresponding order of the radial-velocity standard stars α Arietis, Arcturus, Aldebaran and 5 Serpentis, used as templates. The radial velocity values of the standard stars were taken from Evans (1967) and Duflot et al. (1995).

Spectral regions heavily affected by telluric lines (such as the λ 6276−6315 series of O_2) were excluded from the cross-correlation.

The radial velocity measurements are weighted means of the individual values deduced from each order. Each of these individual values was weighed as $W_{\rm i} = \frac{1}{\sigma_{\rm i}^2}$. The standard errors of the weighed means were computed according to the usual formula (see e.g. Topping 1972) on the basis of $\sigma_{\rm i}$ errors in the RV values for each order. The latter are computed according to the fitted peak height and the anti-symmetric noise as described by Tonry & Davis (1979).

The orbital period was determined by applying the periodogram technique (Scargle 1982). The CLEAN iterative deconvolution algorithm (Roberts et al. 1986) was used to eliminate the effect of the observation spectral window in the power spectrum. The maximum of the power spectrum yields a period of $P_{\rm orb}$ = 21.3675 days, in agreement with the orbital period of 21.3 days and the photometric period of 21.5 ± 0.3 days given by Henry et al. (1995).

The observational points and the best-fit sinusoidal solution (eccentricity equal to 0) are plotted in Figure 1. Error bars, when larger than data points, are also displayed.

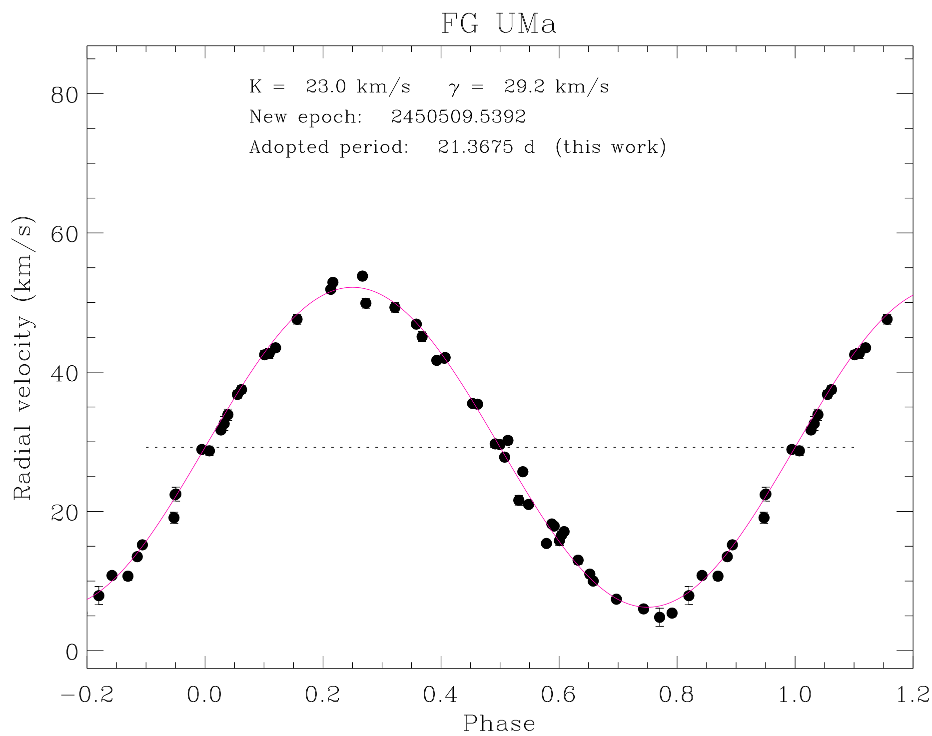

Figure 1. Radial velocity curve and best-fit solution of FG UMa

Table 1 lists the orbital and physical parameters derived from our circular solution.

The low value of the mass function does suggest a low-mass secondary or a low-inclination orbit. The latter hypothesis is consistent with the absence of eclipses in the light curve (Henry et al. 1995).

Let us make some considerations about the spectral types and masses of FG UMa components.

Table1. Orbital parameters for the primary component of FG UMa.

Element	Present solution
K_1	22.97 ± 0.08 (km s^{-1})
γ_1	29.21 ± 0.06 (km s^{-1})
$T_{\rm conj}$	2450509.539 ± 0.010 (JD)
P	21.3675 ± 0.0100 (day)
$a_1 \sin i$	$(6.75 \pm 0.02) \times 10^6$ km
$f(m)_1$	0.02685 ± 0.00039 ($M_\odot$)

Unpublished photometric observations obtained at Catania Observatory by A. Frasca in March-April, 2000, yield a V magnitude ranging from $7\overset{m}{.}26$ to $7\overset{m}{.}37$, and a $B-V$ colour going from 0.97 to 1.01 mag. The V magnitude and $B-V$ colour index reported in the *Hipparcos Catalogue* (ESA 1997) are 7.39 and 1.004 mag, respectively. Henry et al. (1995) give $V = 7.452$ mag.

With a distance of 175 ± 25 pc (ESA 1997) we estimate an average absolute magnitude $M_{\rm V} = 1.0 \pm 0.3$ mag which is typical of a giant star, well above the subgiant branch. The $B-V$ colour is consistent with a spectral type classification G9−K0 III, for which a radius of 10−15 $R_\odot$ is expected (Gray 1992, Schmidt-Kaler 1982). The $v \sin i = 18$ km s^{-1} given by Fekel (1997) leads to a minimum radius of $R_1 \sin i = 7.6$ $R_\odot$. So, an inclination of the rotation axis of about 30°−50°can be estimated. For a star of such an evolutionary stage, a mass of about 2.3−2.9 $M_\odot$ can be inferred (see e.g. Straizys & Kuriliene 1981, Gray 1992).

We have also noted that the spectrum of the inactive K0 III-type star 34 Lyn (Upgren & Staron 1970), broadened to $v \sin i = 18$ km s^{-1}, perfectly reproduces the FG UMa photospheric spectrum, while the G8 IV inactive star 31 Aql leads to a poor comparison with the FG UMa spectrum.

A rough guess of the secondary-star mass can be achieved through the mass function derived from our radial velocity curve. Assuming an inclination of 50°and a primary-star mass $M_1 = 2.3 - 2.9\,M_\odot$, we find a mass $M_2 = 0.9 - 1.1\,M_\odot$, for the secondary star. In agreement with the evolutionary times of such two components, the latter star may be still on the main sequence. Its spectral type should be between G0 V and G8 V and, consequently, its absolute magnitude should be in the 4.5−5.5 mag range. This implies a magnitude difference of about 3.5−4.5 mag between the primary and secondary component, i.e. the secondary would contribute only 2−5 % of the total flux at red wavelengths.

This combination of spectral types and magnitudes can explain why only the primary component is visible in our spectra. High-resolution spectroscopy with very high signal-to-noise ratio in the blue-UV region could show the contribution of the secondary component to the spectrum.

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