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IS GLIESE 410 OR BD+23° 2297 THE VARIABLE STAR?

The dM1 star, Gliese 410, was reported as a photometric variable star by Bopp et al. (1983). It apparently displayed V-band modulation with an amplitude of 0.1 magnitudes and a period of 2.935 days. Such a short period in a star with a deep convection zone is likely to give rise to magnetic activity in its outer atmosphere, leading to chromospheric and coronal emission. Subsequent spectroscopy has shown that Gliese 410 is mildly active. It has a chromospherically filled Hα line (although it is not in emission) and has modest emission lines at Ca II H and K (Panagi & Mathioudakis 1993). We have compared Gliese 410 with other dwarfs that have similar known periods and spectral types. Gliese 388 (AD Leo - P=2.7 days), Gliese 490A (BF CVn - P=3.17 days) and Gliese 803 (AU Mic - P=4.87 days). These all show Hα in emission, have other chromospheric lines that are up to an order of magnitude stronger than in Gliese 410, and are considered to be amongst the most active late-type stars in the solar neighbourhood. If Gliese 410 does have a 2.935 day period, then it is anomalously under-active.

Bopp et al. (1983) used the comparison star BD+23° 2297 in their investigation. The V and B-V magnitudes of this star are given as 8.70 ± 0.35 and 0.72 ± 0.13 by the *Hipparcos* Input Catalogue (Turon et al. 1992), in reasonable agreement with the spectral class of G5 (given in the SAO catalogue), if the star is a dwarf. This star lies within the error circle of a *ROSAT* Wide Field Camera (WFC) EUV source in the most recent WFC catalogue (Pye et al. 1994). The EUV source is designated 2RE J1101+223 in IAU nomenclature, and BD+23° 2297 has been positively identified as the optical counterpart, on the basis of chromospheric emission at Ca II H and K. A rough calculation of the EUV to bolometric luminosity yields a value of $\sim 2 \times 10^{-4}$, which is characteristic of the most magnetically active stars - usually young, rapid rotators or close binary systems (Jeffries et al. 1991). BD+23° 2297 is therefore very likely to show short-period photometric variability caused by starspots rotating across the visible surface, and may be the true source of the variability seen by Bopp et al. (1983).

BD+23° 2297 has been observed spectroscopically at the 2.5 m Isaac Newton

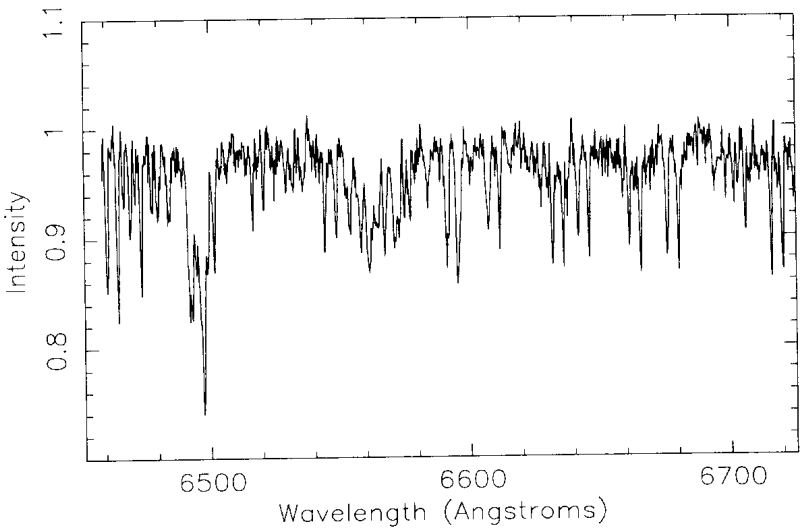

Figure 1: A spectrum of BD+23° 2297 in the Hα region.

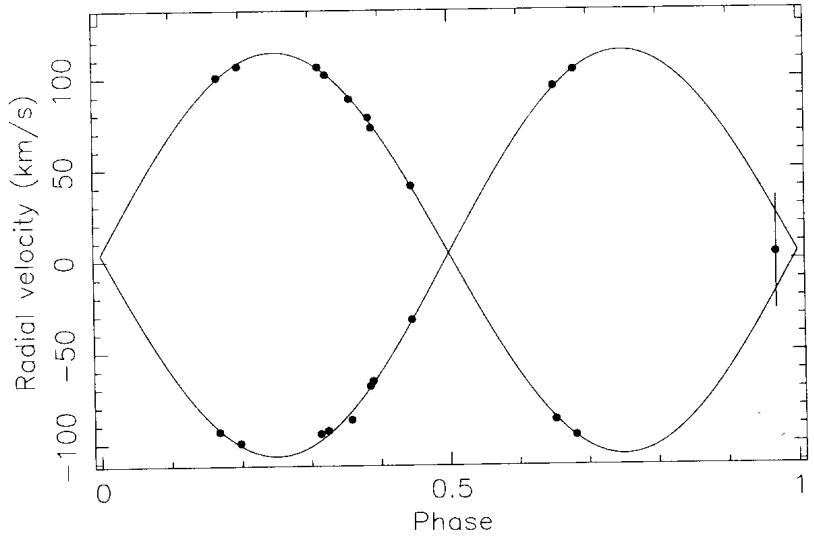

Figure 2: The radial velocity curve folded with the ephemeris HJD 2449055.132+1.528E. Errors are generally smaller than 2 km s^{-1}.

Telescope, with an intermediate dispersion spectrograph and a CCD camera. The spectra obtained were in the red and had a resolution of 0.44Å. BD+23° 2297 is clearly a short-period, double-lined spectroscopic binary and has a Hα feature that appears to be chromospherically filled in (see Figure 1). Analysis of a radial velocity curve taken over 6 nights (Figure 2) yields the following orbital elements. Period = (1.528 ± 0.006) days, K1 = K2 = (110 ± 2) km s^{-1}, $\gamma = 3.9 \pm 2.3$ km s^{-1} and zero eccentricity. If the stars are tidally locked, as they usually are in short-period systems, then starspot modulation with the orbital period might be expected. A consideration of the frequencies involved quickly reveals that aliases with a one day period would produce a signal at a period of 2.89 ± 0.02 days, very close to the period obtained by Bopp et al. (1983). Bopp et al. do not present their raw data, so we cannot make a detailed examination of this hypothesis. Nevertheless, the aliased period is sufficiently close that spot migration or differential rotation could explain the remaining discrepancy.

In summary, we have found that BD+23° 2297, a star used as a comparison to derive the rotation period of Gliese 410, is likely to be variable itself. If Gliese 410 *is* the true variable, it is decidedly under-active for its rotation rate. BD+23° 2297 is a short-period SB2, and the orbital period aliased with a 1 day^{-1} frequency could produce the modulation period found for Gliese 410. Further photometry of both stars is needed to resolve the issue.

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