COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5356

Konkoly Observatory
Budapest
17 December 2002

HU ISSN 0374 – 0676

A NEW VARIABLE FAINT CARBON STAR IN THE M92 FIELD

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This paper announces the discovery of the second variable high latitude carbon star (FHLCS), J1710.4+4329, by the variability and proper motion (VPM) survey in the M92 field. The VPM survey is a search project for variable sources in two 10 square degrees fields around the globular clusters M3 and M92. Although aimed at the detection of active galactic nuclei, variable stars are found as well by the VPM survey. For example, we re-detected the FHLCS J1714.9+4210 (Meusinger & Brunzendorf 2001) which is one of the most variable stars among the ∼ 20 000 star-like objects in the database for the M92 VPM field.

The new FHLCS J1710.4+4329 was also classified as a quasar candidate because of its significant variability in combination with a zero proper motion. Spectroscopic follow-up observations revealed a carbon star. The basic data on positions (J2000.0) and magnitudes are summarized in Table 1. The R magnitude is taken from the GSC-II. The sources of all other data are digitized Tautenburg Schmidt plates reduced in the framework of the VPM survey. For a detailed discussion of the observational material and the data reduction see Brunzendorf & Meusinger (2001, 2002). There is no entry in the SIMBAD database at the position of J1710.4+4329. In particular, the star is registered neither in the GCVS (Kholopov et al. 1998) nor in the carbon star database (Alksnis et al. 2001). With J1710.4+4329, the number of known C stars in the VPM field around M92 increases to four. The corresponding C star surface density of > 0.5 per square degree is a factor of ∼ 10 larger than the mean value (lower limit) from the SDSS (Margon et al. 2002). A remarkable C star overabundance in this field has been noticed already by Kurtanidze & Nikolashvili (2000).

Table 1. Basic data for FHLCS J1710.4+4329.

Parameter	Value
α	$17^{\mathrm{h}}\,10^{\mathrm{m}}\,27\overset{\mathrm{s}}{.}0$
δ	$+43^\circ\,29'\,24\overset{''}{.}4$
$U_\circ$	$18\overset{\mathrm{m}}{.}26\pm0\overset{\mathrm{m}}{.}26$
$B_\circ$	$17\overset{\mathrm{m}}{.}51\pm0\overset{\mathrm{m}}{.}08$
$V_\circ$	$15\overset{\mathrm{m}}{.}96\pm0\overset{\mathrm{m}}{.}10$
R	$15\overset{\mathrm{m}}{.}45\pm0\overset{\mathrm{m}}{.}40$
$\mu_\alpha \cos\delta$	$-0.7 \pm 0.9\,\mathrm{mas\,yr^{-1}}$
μ_δ	$-0.3 \pm 0.8\,\mathrm{mas\,yr^{-1}}$

A low-dispersion spectrum (resolution ~ 20 Å) of J1710.4+4329 was obtained in July 2002 with CAFOS at the 2.2 m telescope of the German-Spanish Astronomical Centre on Calar Alto, Spain, equipped with a B-400 grism and a SITe1d CCD. The raw spectrum was reduced by means of standard MIDAS procedures. At first glance, the spectrum of J1710.4+4329 (Fig. 1) resembles that one shown by Green et al. (1992) for the proper motion carbon star CLS50. The Swan C_2 bands are very pronounced. On the other hand, the sharp bandhead of C_2 at λ6191Å is present in CLS50 but not in J1710.4+4329. Following Green et al., this feature can be used as an indicator for dwarf carbon (dC) stars.

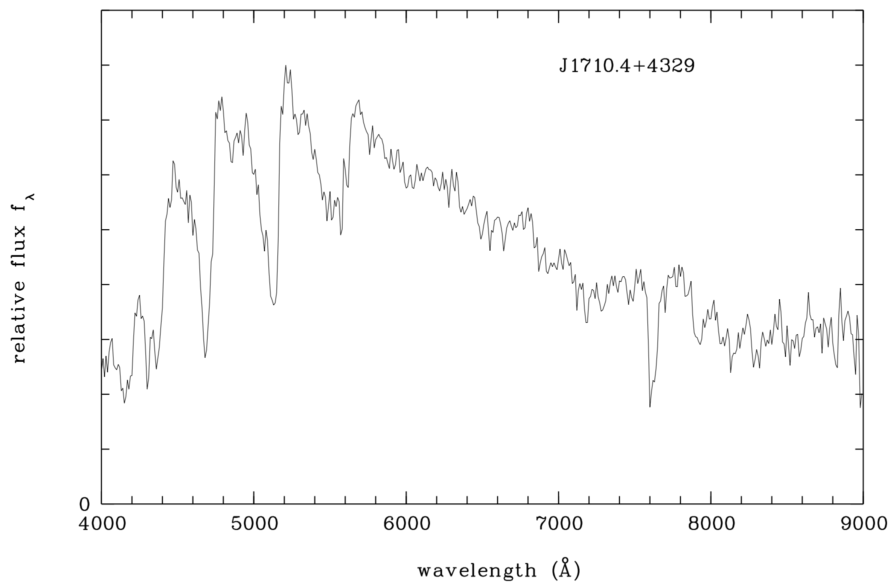

Figure 1. Flux-calibrated low-dispersion spectrum (relative flux f_λ) of J1710.4+4329.

In the context of the VPM survey, the strength of variability of an object is measured by means of B-band variability indices. The variability index of an object is determined by the number of measured epochs and the measured magnitude scatter in units of the typical magnitude scatter at the same magnitude. The index is directly related to the probability of an object to be variable (see Brunzendorf & Meusinger 2001 for more details). In a first version of the survey in the M92 field, variability indices were computed from the reduction of 117 B plates taken between 1964 and 1997 (Brunzendorf & Meusinger 2001). A completely revised photometric data reduction (Brunzendorf & Meusinger 2002) resulted in a substantial improvement of the photometric accuracy at the faint end ($B \approx 20$) for a reduced number of epochs. At the magnitude of J1710.4+4329, the mean photometric error (standard deviation) is $\sigma_0(B) = 0.055 \pm 0.010$. The full range of measured magnitudes for J1710.4+4329 is $B = 17\overset{\mathrm{m}}{.}35 - 17\overset{\mathrm{m}}{.}67$ (Fig. 2a) with a standard deviation $\sigma = 0.08$. The corresponding variability index of $I_\sigma = 3.3$ means that J1710.4+4329 is variable on a significance level larger than 99.9%. With $I_\sigma > 2$, J1710.4+4329 was classified as a high-priority quasar candidate. 86% of the high-priority candidates were spectroscopically confirmed as quasars (Brunzendorf & Meusinger 2002). This result illustrates that the high-priority VPM quasar candidates constitute a remarkably clean sample of variables.

Another robust method to detect variability from small numbers of unevenly sampled data is provided by structure function (SF) analysis. The first order SF of B magnitudes is defined as $S(\tau) = \langle [B(t+\tau) - B(t)]^2 \rangle$, where τ is the time-lag between two observations and the angular brackets indicate the time-average. For a stationary random process with a variability timescale $\tau_{\rm min} \ll t_{\rm var} \ll \tau_{\rm max}$ the SF increases from $S = 2\sigma_0^2$ for $\tau \ll t_{\rm var}$ to $S = 2\sigma^2$ for $\tau \gg t_{\rm var}$, where σ_0^2 is the variance due to measurement noise and σ^2 is the total variance. The plateau of the SF at $\tau > t_{\rm var}$ can be used to derive a physically meaningful characteristic variability time scale. (For more details see e.g., Hughes et al. 1992; Meusinger et al. 1994; Simonetti et al. 1985). The SF becomes more complicated if variability is a multi-modal process with different timescales. The SF from the lightcurve of J1710.4+4329 (Fig. 2, right) suggests a dominant long-term variability mode with a timescale of a decade or longer. This is consistent with the high long-term variability index $I_\Delta = 2.1$ from the VPM survey (for definitions see Brunzendorf & Meusinger 2001). Smaller fluctuations on shorter timescales ($< 1\,$yr) are also indicated by the SF.

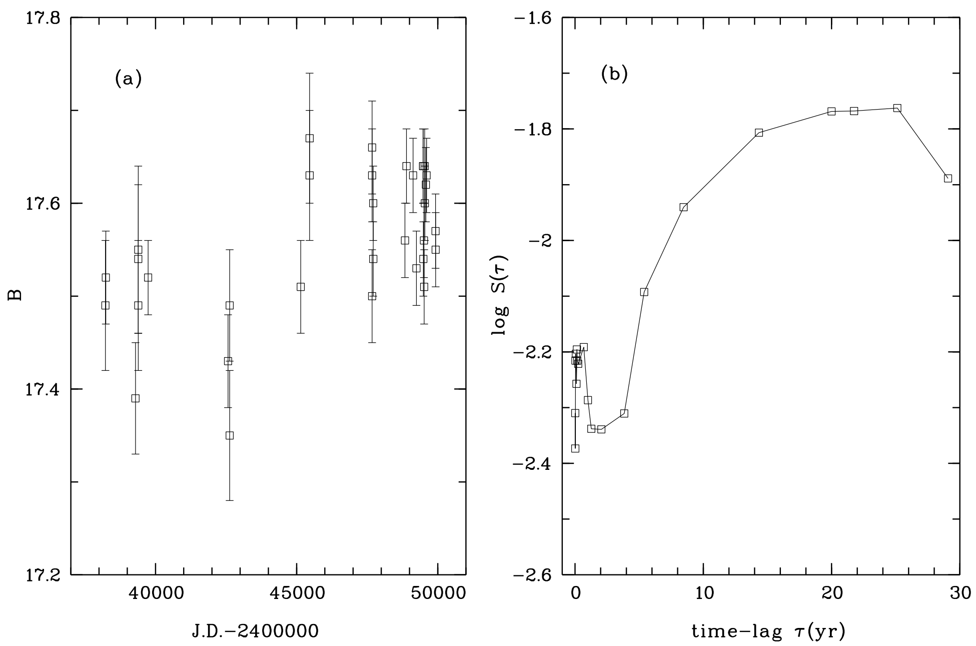

Figure 2. (a) Lightcurve $B(t)$ and (b) first-order structure function $S(\tau)$ for J1710.4+4329.

A comparatively small number of U and V Schmidt plates were measured in the framework of the VPM survey. The U and V magnitudes were used for colour information only. The magnitude measurements in the different passbands have different time baselines. In order to minimize the effect of long-term variability on the colour indices the mean magnitudes given in Table 1 are related to the epoch interval 1968±2 since the distribution of the observing epochs is similar for the three bands in this interval. The magnitudes are corrected for standard galactic extinction. The extinction calculation from the NED, following Schlegel et al. (1998), provides $A_{\rm U} = 0.082$, $A_{\rm B} = 0.065$, and $A_{\rm V} = 0.04$. No instrumental colour-corrections have been applied since the Tautenburg photographic colour system closely matches the Johnson system.

Carbon stars can be dwarfs, subgiants, giants, or supergiants. The galactocentric distance R and the height z above the galactic plane could therefore be as large as $(R, z) \approx$(60 kpc, 35 kpc) for J1710.4+4329. The real distance depends of course on the luminosity class and on the amount of extinction by circumstellar dust which are both unknown. For a nearby late-type dwarf a non-zero proper motion is expected. Proper motion data were derived from the astrometric reduction of 135 B plates with a baseline of more than three decades and were transformed into the reference frame of more than 600 quasars and unambiguously identified galaxies. The absolute proper motion of J1710.4+4329 is smaller than the detection threshold of less than 1 mas yr^{-1} (Table 1). For comparison, the components of the mean absolute proper motion derived for the field stars are $(-3.4 \pm 0.1, -4.3 \pm 0.1)$ mas yr^{-1} with a mean total proper motion of μ =6 mas yr^{-1}. The possibility that J1710.4+4329 has by chance such a small proper motion can be rejected on a significance level larger than 98%. As for FHLCS J1714.9+4210 (Meusinger & Brunzendorf 2001), the zero proper motion of J1710.4+4329 does not support an interpretation as a nearby dC.

Acknowledgments:

This research is based on observations made with the 2.2 m telescope of the German-Spanish Astronomical Centre, Calar Alto, Spain. The research has made use of the SIMBAD database which is operated at CDS, Strasbourg, France, the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory of Technology under contract with the National Aeronautics and Space Administration, and of the Guide Star Catalogue-II (GSC-II) which is a joint project of the Space Telescope Science Institute and the Osservatorio Astronomico di Torino.

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