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LETTER

Letter to the Editor

APMPM J0237-5928: a new nearby active M5 dwarf detected in a high proper motion survey of the Southern sky

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Abstract. A new bright ($R = 13.4$) high proper motion star has been detected within our survey of the Southern sky using APM measurements of UK Schmidt plates (Scholz et al. 1999). This star, APMPM J0237-5928 showing the largest proper motion ($\mu = 0.77$ arcsec/yr) among the newly discovered relatively bright ($11 < R < 15$) proper motion stars in 40 UKST fields, was identified with an X-ray source in the ROSAT All Sky Survey, 1RXS J023630.5-592827. The optical spectrum is typical of an M5 dwarf and shows strong emission lines. An effective temperature $T_{\rm eff}$=3100 K and solar metallicity were determined using "NextGen" model atmospheres for M dwarfs (Hauschildt, Allard & Baron 1999). A distance between 11 and 14.5 pc is estimated based on the spectral type and on the comparison of the observed spectrum with the models. With this distance we determine the relatively high X-ray luminosity $\log L_X = 27.8$ for a late-type M dwarf. The heliocentric space motion was obtained as $(U, V, W) = (-39, -28, -27) \pm (8, 5, 6)$ km s^{-1}.

Key words: stars: individual: APMPM J0237-5928 – stars: activity – stars: late-type – stars: kinematics – stars: distances

1. Introduction

One of the main search criteria for finding nearby low-luminosity stars is their high proper motion. The global proper motion catalogues of Luyten, particularly the LHS catalogue (Luyten 1979) and the NLTT catalogue (Luyten 1979-80, Luyten & Hughes 1980) represent the most important sources for the identification of low-luminosity stars.

In fact, the proper motions of all 58 stars in the Catalogue of Nearby Stars (CNS3) of Gliese & Jahreiß (1991) which are within 5 pc of the Sun exceed 0.5 arcsec/yr. From about 280 stars within 10 pc, there is only one M dwarf with a proper motion below the NLTT limit of 0.18 arcsec/yr. Fleming (1998) used X-ray observations of the ROSAT All-Sky Survey to identify M dwarfs within 25 pc of the Sun that are missing from the CNS3. His aim was to find young stars with small space motions not present in proper motion catalogues. Gliese, Jahreiß & Upgren (1986) claimed that within 13 pc of the Sun the CNS3 should be complete for stars with $M_V < 13$ (around spectral type M4). Fleming (1998) found five M dwarfs with the above conditions, which are not in the CNS3. But all of these stars are catalogued proper motion stars and just nobody ever measured the distance to them.

In the southern sky with $\delta < -33^\circ$ the proper motion catalogues are known to be incomplete. Therefore, a new high proper motion survey was started (Scholz et al. 1999). The main aim of this survey is to complete the proper motion catalogues (with $\mu > 0.3$arcsec/yr) at fainter magnitudes and to carry out follow-up spectroscopy for the most interesting faint objects, particularly low-luminosity white dwarfs and late-type M dwarfs. Nevertheless, relatively bright stars ($11 < R < 15$), so far not known to have large proper motions, were also found in this survey.

Here we present the discovery of a nearby late-type M dwarf identified with an X-ray source and showing emission lines in its optical spectrum.

2. The high proper motion discovery

The new proper motion survey in the southern hemisphere is based on APM measurements of sky survey plates taken with the UK Schmidt telescope. For the pilot study (Scholz et al. 1999), 40 UKST survey fields covering mainly the region between 0^h and 7^h in right ascension and -63° and -32° in declination (about 1000 square degrees) were selected. With a typical epoch difference between the B_j and R UKST plates of about 15 years the survey intends to find all stars with magnitudes $11 < R < 20$ with proper motions exceeding 0.3 arcsec/yr.

Among all newly discovered bright ($11 < R < 15$) high proper motion stars in Scholz et al. (1999), APMPM J0237-5928 shows the largest total proper motion. The proper motion was obtained from one pair of plates with an epoch difference of

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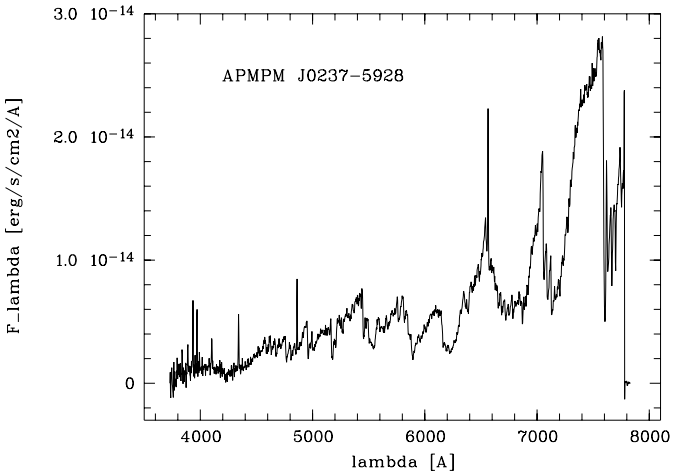

Fig. 1. The spectrum of APMPM J0237-5928. The spectrum is typical of an M5 star and shows the Balmer lines from H_α to H_δ clearly in emission.

$\sim$16 years as $(\mu_\alpha \cos\delta, \mu_\delta) = (+570, +510) \pm (20, 20)$ mas/yr. The new high proper motion star with the coordinates (J2000) $\alpha = 2^h36^m31\overset{s}{.}84, \delta = -59°28'9\overset{''}{.}6$ (at epoch 1991.78) was identified with the X-ray source 1RXS J023630.5-592827 with a separation of about 21 arcsec.

3. The observed spectrum

Spectroscopic observations of high proper motion stars were obtained at Sutherland on the 1.9m Radcliffe Telescope of the SAAO during the nights of 10th-16th November 1998. The spectrum of APMPM J0237-5928 (Fig. 1) was observed on UT 1998 November 10. A 300 line/mm grating was used in the "grating" spectrograph with a SITe 1.8kx1k CCD as the detector. With this combination each CCD pixel covered 2.28Å per pixel, with an effective spectral resolution of 5Å. The spatial resolution was $0.3''$ per pixel. The central wavelength for the observations was chosen such that the final wavelength coverage was in the range 3850Å-7700Å. The lower limit includes the useful diagnostic Ca H,K lines in addition to the higher order member of the Balmer series, while the upper limit covers sufficient TiO and VO molecular bands to spectral type late M stars.

A series of spectrophotometric standard stars were observed each night to provide flux calibration information, although we note that the slit position angle for this instrument is fixed E-W leading to problems accurately flux calibrating data taken over a wide range of airmass. CuAr arcs were taken periodically each night to monitor spectrograph flexure and hence provide an accurate wavelength calibration. Two to three radial velocity standards were also observed each night, since for some objects we wanted to derive reasonably accurate (10–20 km s^{-1}) radial velocities. In these cases CuAr arcs were taken after each target or radial velocity standard observation on sky. Further checks on the wavelength calibration were done by cross-correlating the derived sky spectra, since, at least, at the red end of the spectrum, there are sufficient sky emission lines to provide a diagnostic at the 1/10th pixel level. Standard IRAF tasks were used to bias-correct, flat-field and extract the spectra in pseudo-real time at the telescope.

The radial velocity obtained for APMPM J0237-5928 is $+34 \pm 7$ km s^{-1}.

4. Spectral analysis

The spectral type of APMPM J0237-5928 has been determined using the spectral features described in Kirkpatrick, Henry & McCarthy (1991) and in Reid, Hawley & Gizis (1995). The ratio A from Kirkpatrick, Henry & McCarthy (1991) is 1.39 and the TiO5 index of Reid, Hawley & Gizis (1995) is 0.32. Both indices indicate most clearly the spectral type in the respective papers and both determine APMPM J0237-5928 to be an M5 star. According to Bessel (1995), a typical M5 star has an absolute R magnitude of 13.21. Without extinction, this places APMPM J0237-5928 with the APM measured $R = 13.4$ at a distance of 11.0 pc. Using the absolute R magnitude of 12.58 given by Leggett (1992) for M5 stars, we get a distance of 14.5 pc.

We have also used the so-called "NextGen" grid of model atmospheres for M dwarfs (Hauschildt, Allard & Baron 1999) available via anonymous ftp from the authors for determining the effective temperature and a scaled metallicity. We used several spectral ranges to compare the observed spectrum with models for various effective temperatures (2900 K, 3000 K, 3100 K, 3200 K) and metallicities (-0.5, 0.0). We kept log(g) fixed at 5.0 since log(g) influences most prominently high resolution line profiles (Schweitzer et al. 1996). The parameters for the best fitting models are $T_{\rm eff} = 3100 \pm 100$ K and solar metallicity. The best fit was decided by a χ^2 technique and by eye. The 2900 K models have kindly been made available by P. H. Hauschildt (private communication) and contain the same input physics as the NextGen models. The derived stellar parameters are typical of an M5 dwarf and in agreement with other recent studies (e.g. Leggett et al. 1996)

It is, however, important to mention that the NextGen grid is already superseded by newer developments for the coolest atmospheres in this grid (Hauschildt, 1999, private communication). The use of these NextGen models enabled us to compare the derived stellar parameters with the evolutionary models of Baraffe et al. (1998) who also used the NextGen grid of model atmospheres. The comparison yields under the assumption of APMPM J0237-5928 having reached the main sequence a mass of 0.13 ± 0.01 M$_\odot$ and an R magnitude of $M_R = 13.0 \pm 0.4$. Without extinction, this places APMPM J0237-5928 at a distance of 12.0 ± 2 pc.

5. Space motion

Combining the proper motion and radial velocity with the distance estimate of 12.0 ± 2 pc, we obtained a heliocentric space velocity (Johnson & Soderblom 1987) of $(U, V, W) = (-39, -28, -27) \pm (8, 5, 6)$ km s^{-1}. Although this space velocity is consistent with the kinematic class of young disk stars, it was noted by Fleming, Schmitt & Giampapa (1995) that kinematic class is a poor age indicator for the nearby stars.

6. X-ray luminosity

The inferred spectral type M5 places this object into a range of spectral classes where chromospheric activity is present in about half of all M dwarfs (see e.g. Hawley, Gizis & Reid 1996). Schmitt, Fleming & Giampapa (1995) presented a complete X-ray survey of all known M and K stars in the immediate solar vicinity (distances less than 7 pc). They found that the observed X-ray luminosity function of K and M dwarfs spans almost four orders of magnitude ($25.4 < \log L_X < 29.1$). However, the stars with $M_V > 14$ do not seem to exceed X-ray luminosities of 10^{28} ergs s^{-1}. With an ROSAT All Sky Survey (see e.g. Belloni, Hasinger & Izzo 1994) count rate of 0.0669 s^{-1} and X-ray hardness ratio of -0.49 and the estimated distance of 12 pc for APMPM J0237-5928 = 1RXS J023630.5-592827, we determine $\log L_X = 27.8$ using the conversion factor CF given in Schmitt, Fleming & Giampapa (1995). This is a relatively large $\log L_X$ value, but still below the observed limit for late-type M dwarfs mentioned by Schmitt, Fleming & Giampapa (1995).

7. Conclusions

We have discovered a bright ($R = 13.4$) M5 dwarf on the basis of a new high proper motion survey in the southern sky (Scholz et al. 1999). The star shows emission lines in the optical spectrum and a relatively high X-ray luminosity of $\log L_X = 27.8$. The distance estimate of 12 ± 2 pc based on comparison of the observed spectrum with models is in agreement with two different values (11 and 14.5 pc) obtained from the spectral type. An effective temperature $T_{\rm eff}$=3100 K and solar metallicity were determined using "NextGen" model atmospheres for M dwarfs (Hauschildt, Allard & Baron 1999). The obtained radial velocity of $+34 \pm 7$ km s^{-1} and proper motion of $(\mu_\alpha \cos\delta, \mu_\delta) = (+570, +510) \pm (20, 20)$ mas/yr allowed to calculate a heliocentric space velocity of $(U, V, W) = (-39, -28, -27) \pm (8, 5, 6)$ km s^{-1}. The example of APMPM J0237-5928 shows that with our new proper motion survey we are able to find not only faint ($R \sim 18...20$) candidates for very low-luminosity objects but also relatively bright ($R \sim 11...15$) nearby stars.

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References

Baraffe I., Chabrier G., Allard F., Hauschildt P.H., 1998, A&A 337, 403
Belloni T., Hasinger G., Izzo C., 1994, A&A 283, 1037
Bessel M.S., 1995, In: Tinney C.G. (ed.), The Bottom of the Main Sequence - and beyond, Proc. ESO Workshop, Springer-Verlag Berlin Heidelberg New York, p. 123
Fleming T.A., 1998, ApJ 504, 461
Fleming T.A., Schmitt J.H.M.M., Giampapa M.S., 1995, ApJ 450, 401
Gliese W., Jahreiß H., Upgren A.R., 1986, in Smoluchowski R., Bahcall J., Matthews M. (eds.), The Galaxy and the Solar System, Univ. Arizona Press, Tucson, p.13
Gliese W., Jahreiß H., 1991, Preliminary Version of the Third Catalogue of Nearby Stars, computer-readable version on ADC Selected Astronomical Catalogs Vol.1 - CD-ROM
Hawley S.L., Gizis J.E., Reid I.N., 1996, AJ 112, 2799,
Hauschildt P.H., Allard F., Baron E., 1999, ApJ 512, 377
Johnson D.R.H., Soderblom D.R., 1987, AJ 93, 864
Kirkpatrick J.D., Henry T.J., McCarthy D.W., 1991, 77, 417
Leggett S.K., 1992, ApJS 82, 351
Leggett S.K., Allard F., Berriman G., Dahn, C.C., Hauschildt P.H., 1996, ApJ 104, 117
Luyten W. J., 1979, LHS Catalogue. Second Edition. Minneapolis, University of Minnesota Press
Luyten W. J., 1979-1980, New Luyten Catalogue of Stars with Proper Motions Larger than Two Tenths of an Arcsecond, Minneapolis, University of Minnesota, computer-readable version on ADC Selected Astronomical Catalogs Vol.1 - CD-ROM
Luyten W. J., Hughes H. S., 1980, Proper Motion Survey with the Forty-Eight Inch Schmidt Telescope. LV. First Supplement to the NLTT Catalogue, Minneapolis, University of Minnesota, computer-readable version on ADC Selected Astronomical Catalogs Vol.1 - CD-ROM
Reid I.N., Hawley S.L., Gizis J.E., 1995, AJ 110, 1838
Schmitt J.H.M.M., Fleming T.A., Giampapa M.S., 1995, ApJ 450, 392
Scholz R.-D., Irwin M., Ibata R., Jahreiß H., Malkov O.Yu., 1999, A&A, submitted
Schweitzer A., Hauschildt P.H., Allard F., Basri G., 1996, MNRAS 283, 821