The first spectroscopically confirmed Mira star in M33

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ABSTRACT

We present photometry and moderate-resolution spectroscopy of the luminous red variable [HBS 2006] 40671, originally detected as a possible nova in the galaxy M33. We find that the star is a pulsating Mira-type variable with a long period of 665 d and an amplitude exceeding 7 mag in the \textit{R} band. [HBS 2006] 40671 is the first confirmed Mira-type star in M33. It is one of the most luminous Mira-type variables. In the \textit{K} band its mean absolute magnitude is \(M_K = -9.5\), while its bolometric magnitude measured at maximum light is also extreme, \(M_{\text{bol}} = -7.4\). The spectral type of the star at maximum is M2e–M3e. The heliocentric radial velocity of the star is \(-475\) \text{km s}\(^{-1}\). There is a large negative excess \((-210\) \text{km s}\(^{-1}\)) in the radial velocity of [HBS 2006] 40671 relative to the average radial velocity of stars in its neighbourhood, pointing at an exceptional pecular motion of the star. All the extreme properties of the new Mira star make it an important candidate for further studies.

Key words: stars: AGB and post AGB – stars: variables: general – galaxies: general – galaxies: individual: M33

1 INTRODUCTION

The General Catalogue of Variable Stars (GCVS: Kholopov et al. 1985) gives a definition of Mira (Omicron) Ceti-type variables: ‘These are long-period variable giants with characteristic late-type emission spectra (Me, Ce, Se) and variation amplitudes from 2.5 to 11 magnitudes in \textit{V}. Their periodicity is well pronounced, and the periods lie in the range between 80 and 1000 d. Infrared amplitudes are usually less than those in the visible and may be <2.5 mag. For example, in the \textit{K} band they usually do not exceed 0.9 mag.’ Due to the large amplitude of variability exceeding 2.5 mag in the \textit{V} band, Mira variables in nearby galaxies may be confused with optical novae. The confusion can be solved if subsequent spectral or photometric investigations reveal a Mira-type star with a cool M-type spectrum and a long periodic variability. Recently, peculiar red novae were introduced as a new class of astrophysical objects (Goranskij & Barsukova 2007). This class is represented by stars such as V838 Mon, V4332 Sgr and V1006/7 in M31. Nova Sgr 1943 (V1148 Sgr) may possibly also belong to this class. Their remnants may be cool luminous L- or M-type supergiants, which in the course of discovery may be confused with both Mira-type stars and classical novae. Nova Sgr 1943 reached a maximum photometric brightness of 8.0 \text{mag}, and was described by Mayall (1949) as a late K-type star with TiO bands in the spectrum. It was found that the star is not of Mira type, and later the star was lost.

In a search for novae in nearby galaxies one may run into similar problems. A cool supergiant may be misidentified as a nova when an unfiltered CCD image is compared with \textit{B} or \textit{V} images. The M31 nova candidate 2008–09b (Barsukova et al. 2008) turned out to be a star with \textit{M}\textsuperscript{-9} type spectrum. It may be a red nova or even a red supergiant showing no variability at all. There are two additional nova candidates in M31 that turned out to be luminous Mira-type stars: M31N 1995–11e (Shafer et al. 2008a) and M31N 2007–11g (Shafer et al. 2008b). The Mira-type star in IC 1613 described by Kurtvet et al. (2001) has been discovered to be a nova as well (King, Modjaz & Li 1999). In this paper we study a Mira-type star in the galaxy M33 that has been discovered to be a nova candidate.

An outburst of a source with coordinates RA = 0\textdegree 13’34”27’13, Dec = 30°58’42”7 (J2000) in M33 was detected by Nishiyama & Kabashima (private communication). They reported it as a possible nova (with 18.6 \text{mag}) detected in five frames taken around 2009 August 17.807 UT exposed for 60 s using the 0.40-m \textit{f}/9.8 reflector and unfiltered CCD of the Miyaki Argenteus Observatory, Japan, reaching a limiting magnitude of 20.2. Nothing was visible at this location on their previous frames taken on 2008 December 25.559 UT and 2009 August 07.737 UT with limiting magnitudes of 20.0 and 19.4, respectively. The source was confirmed by these authors on 2009 August 18.696. But later they withdrew the interpretation as a possibile nova, as it did not change brightness.

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The source was identified by us with star number 40671 in the photometric survey of variable stars in M33 carried out by Hartman et al. (2006). We will name it hereafter [HBS 2006] 40671. The survey observations were carried out between 2003 August and 2005 January. The authors classify the star as a long-period variable (LPV). During their observations, the star was red with $R - I \approx 2.7$ and $R \gtrsim 20$ mag at maximum and minimum brightness, respectively. The star became extremely red during the registered minimum ($R \gtrsim 25$ mag).

2 OBSERVATIONS

We have carried out spectral observations with the Russian 6-m Big Telescope Alt-azimuth (BTA) telescope using the SCORPIO spectrograph (Afanasiev & Moiseev 2005). The spectrum was taken on 2009 October 9.874 UT over the range 4300–7880 Å with a spectral resolution of 13 Å. The spectroscopy was followed by $BVR_c$ images on the same date. We found the star at a level of 18.8 mag in the $R_c$ band. One more photometric $BVR_c$ observation has been taken with the 1-m Zeiss telescope of the Special Astrophysical Observatory (RAS) on 2009 October 29.9 UT.

We have searched for additional images of this star in the internet archives of different observatories. Dozens of images were found; most of them come from medium-size telescopes equipped with wide-field mosaic CCD cameras. The star position is well placed on frames of the Calar Alto Observatory taken in 1989 and 1998 with the 80/120-cm Schmidt telescope and frames taken in 2000 and 2002 in $BVRI$ bands of the 8.2-m SUBARU telescope of the National Astronomical Observatory of Japan. One $V$-band observation from the 4.2-m William Herschel Telescope and three Sloan Digital Sky Survey (SDSS) $r'$-band observations from the 2.54-m Isaac Newton Telescope were used as well; both telescopes belong to the Isaac Newton Group of Telescopes at the Roque de Los Muchachos Observatory of La Palma, Spain. We also apply one $I$-band measurement obtained from the 4.0-m Mayall telescope image taken in 2001 and published by Massey et al. (2006).

Archival images from the 8.2-m SUBARU telescope, 4.2-m William Herschel Telescope and 2.54-m Isaac Newton Telescope were downloaded as raw FITS files and then processed in the same way as our own 6-m BTA and 1-m Zeiss telescope images. Standard reduction procedures for raw CCD images were applied (bias and dark-frame subtraction and flat-field correction) using the SIMS program. Reduced images of the same series were co-added to improve the signal-to-noise (S/N) ratio and then used for photometry. We used GAIA\footnote{http://ccd.mii.cz/} to perform ‘optimal photometry’ based on fitting of point spread function (PSF) profiles. $B$, $V$, $R$ and $I$ magnitudes for comparison stars were taken from the Local Group Galaxy Survey (LGGS) catalogue of stars in M33 (Massey et al. 2006).

In the case of SDSS $r'$-band images, we computed $r'$ magnitudes for comparison stars from $BVRI$ magnitudes taken from Massey et al. (2006) using empirical colour transformations between the SDSS $ugriz$ system and Johnson–Cousins $UBVRi$ system published by Jordi, Grebel & Ammon (2006).

Nishiyama & Kabashima (private communication) continued their unfiltered observations at the Miyaki Argenteus Observatory, Japan, from 2009 August 18–2010 January 3 and kindly provided us with 16 new images taken in this period. All the photometric measurements of [HBS 2006] 40671 (collected in addition to those of Hartman et al. 2006) are presented in Table 1.

We created a finding chart for the star from a high-quality $R$-band image taken with the Subaru telescope on 2002 November 4 (Fig. 1). A relatively bright visual companion is located 2.1 arcsec north-east of the variable. Massey et al. (2006) catalogued the position of this star as RA = 01$^\mathrm{h}$34$^\mathrm{m}$27.19$^\mathrm{s}$, Dec. = 30°58′44.4″ (J2000) and give $B$, $V$, $R$- and $I$-band magnitudes of 21.40, 21.11, 20.94 and 20.71, respectively. The observations of the LGGS (Massey et al. 2006) were obtained from 2000 October–2001 September. The variable star is not included in the catalogue, as it is only detected on the $I$-band image taken during the survey on 2001 September 18 (the criterion for inclusion in the catalogue is detection in the three bands $B$, $V$ and $R$).

3 THE PERIOD SEARCH AND THE LIGHT CURVE

Most of the data in Table 1 relate to the light curve maximum. Both ascending and descending branches of the light curve are not fully covered. The observations during these phases come mostly from the survey by Hartman et al. (2006). The survey presents observations when the star had a brightness between 22 and 25 mag in the $R$ band. The accuracy of these observations (Hartman et al. 2006) varies from 0.04 mag at $R = 22$ mag to 0.37 mag at $R = 25$ mag.

To search for periodicities we used a method proposed by Lafler & Kinman (1965), which is based on phase-dispersion minimization. In this search we used only the observations in the $R$ band because they represent the best sampling from amongst the total data set.

The periodogram was calculated in the period range between 200 and 7000 d (Fig. 2). The output parameter there is the inverse dispersion value $1/\theta$ described by Lafler & Kinman (1965); maxima in the periodogram correspond to dispersion minima. There are essentially no peaks with period values less than 200 d. This range of periods is not shown in the figure. A period of 665 d shows the highest amplitude. There are two lower amplitude peaks at 3500 and 406 d (Fig. 2). However, these periods give much worse light curves. Longer periods contradict with the fast changes of brightness on ascending and descending branches of the light curve (Hartman et al. 2006). The phased light curve in the $R$ band is presented in Fig. 3. It was calculated with the following light elements:

\[ \text{Max} = 245 \, 5080 + 665E. \]  \hspace{1cm} (1) \]

Eq. 3 shows that we do not resolve, and possibly do not even cover, the minimum of the light curve. The star at minimum brightness is no brighter than $R = 25.4$ mag. The total amplitude of the variability is greater than 7 mag in the $R$ band. Also, the ascending branch is not well covered. Therefore, the epoch of the maximum can only be constrained to ±5 days. However, it is obvious that the light curve of this Mira variable is asymmetric: the ascending branch is steeper than the descending one.

We tried to refine the maximum in the light curve using archival observations from the infrared satellite Spitzer (McQuinn et al. 2007). In five observations on 2004 January 9, July 22 and August 16 and 2005 January 21 and August 25, the star varied over the range 14.24–14.97 mag, 14.16–14.64 mag and 13.66–14.04 mag in the 3.6-, 4.5- and 8-$\mu$m bands, respectively. A maximum is found during 2004 July/August, corresponding to phases in the interval 0.18–0.22 according to equation (1). Therefore the infrared
maximum seems not to be exactly in phase with the optical maximum, but it is very close to it (see Fig. 3).

4 SPECTRUM

The calibrated spectrum of [HBS 2006] 40671 in the 4300–7880 Å spectral region is shown in Fig. 4. Molecular TiO bands dominate this spectral region and the [TiO] lines are not resolved in our spectrum. Its equivalent width is $\text{EW} = 0.28 \text{ mag}$, respectively. These values agree with the spectral type M1–M2 (Smak 1964).

We have also determined the spectral type of the star using [TiO] indices introduced by O’Connell (1973) and measured in our calibrated spectrum. The spectral indices were derived from fluxes measured in 30-Å bandpasses centred at three wavelengths each for [TiO] (6125, 6180 and 6370 Å) and [TiO] (7025, 7100 and 7400 Å) as [TiO] = +0.52 and [TiO] = +0.55, respectively. These index values correspond to spectral class M3. Such a spectrum is natural for Mira variables at maximum light, while at minimum they usually have later spectra.

The $\text{H} \alpha$ emission line of [HBS 2006] 40671 is very narrow and not resolved in our spectrum. Its equivalent width is $\text{EW} = 9 \text{ Å}$. For Fe II we measure a heliocentric radial velocity of $-440 \pm 15 \text{ km s}^{-1}$. That this high radial velocity is not caused by calibration problems was verified by measuring the radial velocity of the [O I] $\lambda 6300$ sky line, which was determined as $0 \text{ km s}^{-1}$ as expected. Also, at a distance of $\sim 1.6 \text{ arcmin}$ from [HBS 2006] 40671, by chance the high-ionization H II region Z.378 (Courtes et al. 1987) was captured in the slit. The heliocentric radial velocity of its $\text{H} \alpha$ line is $-280 \pm 10 \text{ km s}^{-1}$. This velocity is in good agreement with that of the H$ \beta$ radio emission at that position ($-265 \pm 5 \text{ km s}^{-1}$; Reakes & Newton 1978). The difference of 1.6 arcmin between the H II region and the star’s location in the galaxy body may produce a radial velocity shift of $5–10 \text{ km s}^{-1}$. Therefore we find a strong negative excess in the $\text{H} \alpha$ radial velocity of [HBS 2006] 40671 of $-175 \text{ km s}^{-1}$ over the galaxy radial velocity.

To check whether this negative excess of the $\text{H} \alpha$ radial velocity is also reflected in other features of the spectrum of [HBS 2006] 40671, we cross-correlated it with spectra of known standard stars. We used two red variables, V934 Her (HD 154791, 4U 1700+24, M2 III) and...
obtain an orbital velocity of \( \sim 200 \text{ km s}^{-1} \) in a binary of a few solar masses, the orbital period must be less than 10 d and the orbital separation less than 0.2 au. This is impossible due to the huge sizes of Mira variables.

We tried to investigate whether [HBS 2006] 40671 is positioned in front of or behind the disc of M33, which would indicate motion away from or towards the disc, respectively. However, the S/N ratio of the spectrum in the range of expected diffuse interstellar bands was no better than 0.4 mag.

5 DISCUSSION AND CONCLUSION

According to our data from the 6-m and 1-m telescopes, the observed photometric colours of [HBS 2006] 40671 during maximum are \( B - V = 1.6 \) and \( V - R = 1.2 \) mag. Taking into account the distance modulus of M33, \( m - M_\odot = 24.92 \pm 0.12 \) mag (the distance 964 ± 54 kpc, Bonanos et al. 2006), and the Galactic extinction value \( A_V = 0.15 \) mag (Schlegel, Finkbeiner & Davis 1998) we find an absolute magnitude of the star near maximum brightness (\( V = 20.02 \pm 0.05 \) mag at the pulsation phase 0.05) of \( M_V = -5.05 \pm 0.15 \). This is consistent with luminosity classes Ib–Iab. For an M3-type star the bolometric correction amounts to \(-2.34 \) mag (Smak 1966). This leads to a bolometric magnitude in the brightness maximum of \( M_\text{bol} \approx -7.4 \). Unfortunately, we have not enough data to estimate the \( V \)-band pulsation magnitude or mean magnitude.

2MASS data (Skrutskie et al. 2006) show [HBS 2006] 40671 on 1997 December 5, at a pulsation phase of 0.54, at a brightness of 17.30 ± 0.23, 15.89 ± 0.16 and 15.45 ± 0.15 mag in \( J \), \( H \) and \( K \), respectively. There are more observations of the star in the \( JHK \) bands taken from 2005 September 29–December 16 (pulsation phases 0.84–0.96) with the 3.8-m UKIRT telescope equipped with WFCAM (Cioni et al. 2008). The brightness of the star during this period was 16.86, 16.24 and 15.66 mag in the \( J \), \( H \) and \( K \) bands, respectively. These data confirm the typical Mira behaviour,
The first confirmed Mira star in M33

i.e. the decrease of pulsation amplitude with increasing wavelength. However we have not enough data to study the infrared light curve in detail. Kanbur, Hendry & Clarke (1997) found that the $K$-band amplitudes of O Mira variables is smaller for shorter periods. From the relations in that paper, the O Mira variables with periods longer than 420 d should show total $K$ amplitudes smaller than 0.4 mag. We use the 2MASS data for a luminosity estimate. We find an absolute magnitude of $[\text{HBS 2006}] 40671$ of $M_K \sim -9.5$ with a possible error of $\pm 0.15$. Applying a bolometric correction of $+3.3$ mag determined by Bessell & Wood (1984) to this $K$-band magnitude, we find $M_{\text{bol}} = -6.2$.

Feast et al. (1989) present period–luminosity (PL) relations for Large Magellanic Cloud (LMC) Mira variables, where they found that O Mira variables with periods longer than $\sim 420$ d are over-luminous (see also Hughes & Wood 1990). Fitting the over-luminous branch of long-period Mira variables (without the star C2), the status of which is less certain: Feast et al. 1989), we find for our star with 665-d period that the expected mean luminosity is $M_K \sim -9.47$ mag. This agrees well with our estimate from 2MASS data. Using PL relations for bolometric luminosities for over-luminous long-period Mira variables from both Feast et al. (1989) and Hughes & Wood (1990), we find very similar results: the mean expected luminosity for the 665-d star is $M_{\text{bol}} \approx -6.5$ mag. This value is close to $M_{\text{bol}} = -6.2$, found above the 2MASS data taken at minimum. On the basis of our spectral classification, we determined a bolometric luminosity of $\approx -7.4$ mag at the brightness maximum. The bolometric luminosities of O-type Mira variables change notably during the pulsation cycle. Using the relations found by Kanbur et al. (1997), one might expect that in O Mira variables with periods longer than 420 d the difference between maximal and mean bolometric luminosity is 0.5 mag. We conclude that the luminosities of $[\text{HBS 2006}] 40671$ found by us are in line with the statistical relations, but the star’s parameters put it in the extreme tail of these relations.

In the presence of the huge amplitude of $[\text{HBS 2006}] 40671$ in the $R$ band, not less than 7 mag, one might expect an even larger amplitude in the $V$ band (e.g. Barthes Chenevez & Mattei 1996). In long-period Mira variables the amplitude dispersion is very high (Mattei et al. 1997; Hughes & Wood 1990). A visual amplitude in a Mira star with a period $P \sim 665$ d may be as large as 8.3 mag (Mattei et al. 1997). Using relations presented by Hughes & Wood (1990), we estimate the mass of this star as $M \sim 4 M_\odot$. Based on its luminosity and pulsation period, $[\text{HBS 2006}] 40671$ is similar to the Mira-type variable discovered by Kurtev et al. (2001) in the IC 1613 galaxy ($M_K = -9.62$ mag and $P = 640.7$ d). However, the amplitude of the IC 1613 Mira is only 2.5–3 mag in the $R$ band. In the PL plane for $M_K$ luminosities for the LMC, the star $[\text{HBS 2006}] 40671$ is located in the same place as the IC 1613 Mira (Kurtev et al. 2001). Both stars are located in the zone of first-overtone pulsating Mira variables.

Wood, Bessell & Fox (1983) found that long-period variables are grouped into two classes: core-helium-burning supergiants, which are brightest, and asymptotic giant branch (AGB) stars, which are at least 1 mag fainter at a given period. The supergiant LPVs form a distinct PL relation and have lower amplitudes. The PL relation for six core-helium-burning supergiants in M33 was presented by Kinman, Mould & Wood (1987) in their fig. 8. The $K$ magnitude for supergiants with a 665-d period is expected to be 13.9. The 2MASS $K$ magnitude of $[\text{HBS 2006}] 40671$ is 1.5 mag fainter, which suggests that this object is an AGB star. AGB stars in M33 and M31 are discussed in papers by Javadi, van Loon & Mirtorabi (2010) and Rich, Mould & Graham (1993).

Whitelock (2010) discussed a type of long-period variable undergoing a hot bottom burning (HBB) in the base of their convective envelopes. They lie above the PL relation of AGB Mira-type variables. In the LMC they are large-amplitude variable stars, additionally showing lithium and s-process enrichment. As an example, she refers to the 641-d Mira in IC 1613 studied by Kurtev et al. (2001) located above the PL relation. $[\text{HBS 2006}] 40671$ is also located 0.35 mag above the PL relation for AGB stars with periods over 400 d derived by Hughes & Wood (1990), along with three HBB stars studied by Whitelock et al. (2003) in the LMC. We did not find lithium or other s-process elements in our low-resolution spectrum, but the luminosity excess is evident as similar to that in the IC 1613 Mira variable.

We conclude that the star $[\text{HBS 2006}] 40671$ in M33 is an O Mira-type variable with extreme properties. Its pulsation amplitude is not less than 7 mag in the $R$ band, while the period of $\sim 665$ d is one of the longest known for Mira-type variables. The mean absolute magnitude of the star in the $K$ band is $M_K \sim -9.5$. At maximum light its bolometric magnitude is estimated as $M_{\text{bol}} \approx -7.4$. It shows a spectrum of type M2e–M3e.

There is a strong negative excess of $-210$ km s$^{-1}$ in the star velocity relative to the radial velocity of the star’s location projected...
on to the galactic disc. This is the peculiar motion of the star. According to Feast (2007), the velocity dispersion of Galactic O Miras is in the range 30–80 km s$^{-1}$. They belong to Galactic populations ranging from thin disc to extended disc. In spite of the enhanced velocity dispersion of the Galactic Mira stars, the peculiar velocity ranging from thin disc to extended disc. In spite of the enhanced velocity dispersion of the Galactic Mira stars, the peculiar velocity of $\sim 200$ km s$^{-1}$ for [HBS 2006] 40671 is rather large.

The radial velocity of the narrow H$\alpha$ emission line is $+35 \pm 10$ km s$^{-1}$ relative to that of the star itself. Such a shift in the H$\alpha$ emission line is in the range 30–80 km s$^{-1}$ for Mira stars. It can be explained by stellar pulsations and shocks in an expanding atmosphere. All the properties make the new Mira star important for further studies. [HBS 2006] 40671 is the first spectroscopically confirmed Mira star in M33.

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REFERENCES

Afanasiev V. L., Moiseev A. V., 2005, Astron. Lett., 31, 194
Barsukova E., Fabrika S., Sholuhkova O., Valeev A., Goranskij V., Pietsch W., Hornoch K., 2008, Astron. Telegram, 1762
Barthes D., Chenevez J., Mattei J. A., 1996, AJ, 111, 2391
Bessell M. S., Wood P. R., 1984, PASP, 96, 247
Bonanos A. Z. et al., 2006, ApJ, 652, 313
Bonelli E. et al., 2008, A&A, 487, 131
Courtes G., Petit H., Sivan J.-P., Dodonov S., Petitt M., 1987, A&A, 174, 28
Feast M., 2007, in Kerschbaum F., Charbonnel C., Wing R. F., eds, ASP Conf. Ser. Vol. 378. Why Galaxies Care About AGB Stars. Astron. Soc. Pac., San Francisco, p. 479
Feast M. W., Glass I. S., Whitelock P. A., Catchpole R. M., 1989, MNRAS, 241, 375
Galloway D. K., Sokoloski J. K., Kenyon S. J., 2002, ApJ, 580, 1065
Goranskii V. P., Barsukova E. A., 2007, Astron. Rep., 51, 126
Hartman J. D., Bershier D., Stanek K. Z., Beaulieu J.-P., Kaluzny J., Marquette J.-B., Stetson P. B., Schwarzenberg-Czerny A., 2006, MNRAS, 371, 1405
Hughes S. M. G., Wood P. R., 1990, AJ, 99, 784
Jascheke C., Jaschek M., 1987, J. British Astron. Association, 98, 47
Javadi A., van Loon J. Th., Mintorabi M. T., 2010, MNRAS, doi:10.1111/j.1365-2966.2010.17678.x (arXiv:1009.1822)
Jordi K., Grobel E. K., Ammon K., 2006, A&A, 460, 339
Kanbur S. M., Hendry M. A., Clarke D., 1997, MNRAS, 289, 428
Kholopov P. N. et al., 1985, General Catalogue of Variable Stars, 4th edition.
Nauka Publishing House, Moscow [in Russian]
King J. Y., Modjaz M., Li W. D., 1999, IAU Circ., 7287, 2
Kinnin T. D., Mould J. R., Wood P. R., 1987, AJ, 93, 833
Kurtev R., Georgiev L., Borissova J., Li W. D., Filippenko A. V., Treffers R. R., 2001, A&A, 378, 449
Lafler J., Kinnin T. D., 1965, ApJS, 11, 216
Mayall M. W., 1949, AJ, 54, 191
Marrese M. P., Boschi F., Munari U., 2003, A&A, 406, 995
Massey P., Olsen K. A. G., Hodge P. W., Strong S. B., Jacoby G. H., Schlingman W., Smith R. C., 2006, AJ, 131, 2478
Mattei J. A., Foster G., Hurwitz L. A., Malataesta K. H., Willson L. A., Mennessier M. O., 1997, ESA Symposium, 402, 269
McQuinn K. B. W. et al., 2007, ApJ, 664, 850
O’Connell R. W., 1973, AJ, 78, 1074
Reakes M. L., Newton K., 1978, MNRAS, 185, 277
Rich R. M., Mould J. R., Graham J. R., 1993, AJ, 106, 2252
Schlegel D. J., Finkbeiner D. P., Davis M., 1998, ApJ, 500, 525
Shafer A. W., Ciardullo R., Bode M. F., Darnley M. J., Misselt K. A., Nishiyama K., Kabashima F., 2008a, Astron. Telegram, 1834
Shafter A. W., Ciardullo R., Bode M. F., Darnley M. J., Misselt K. A., Nishiyama K., Kabashima F., 2008b, Astron. Telegram, 1851
Skrutskie M. F. et al., 2006, AJ, 131, 1163
Snak J., 1964, ApJS, 9, 141
Snak J., 1966, Acta Astron., 16, 109
Whitelock P. A., 2010, in Sterken C., Samus N., Szabados L., eds, Variable Stars, the Galactic Halo and Galaxy Formation, B. V. Sukarkin Centenary Conference. SAO and Moscow Univ., Moscow, p. 55
Whitelock P. A., Feast M. W., van Loon J. Th., Zijlstra A. A., 2003, MNRAS, 342, 86
Wood P. R., Bessell M. S., Fox M. W., 1983, ApJ, 272, 99

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