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High galactic latitude classical nova KT Eridani: spectroscopic and photometric observational report

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Abstract. We have performed spectroscopic and multi-color photometric observations of a high galactic latitude classical nova KT Eridani. After 12.2 days from maximum light, broad and prominent emission lines of Balmer series, He I, He II, N II, N III and O I can be seen on the spectra. The FWHM of Hα line yields an expansion velocity of approximately 3400 kms^{-1}. From the obtained light curve, KT Eri is a very fast nova, with a decline rate by two magnitude of 6.2 ± 0.3 days. We tried to estimate the absolute magnitude at maximum using the Maximum Magnitude Rate of Decline and distance of KT Eri. Calculated absolute magnitude at maximum is approximately −9. Accordingly, the distance and galactic height are approximately 7 kpc and 4 kpc, respectively. Hence, KT Eri is thought to be located outside of the galactic disk.

Key words. novae; cataclysmic variables; spectroscopy; multi-color photometry

1. Introduction

Classical novae are one type of cataclysmic variable stars that are close binary system of white dwarf and a normal star (for reviews, see Warner 1995 & 2008). Nova eruption is due to the thermonuclear runaway reaction on the surface of the white dwarf. Usual amplitude of eruption is 8 to 15 magnitude. Very few novae have been caught on their rise to maximum, since it takes usually one to three days toward the maximum. The speed class is defined as the time taken to decline by two or three magnitude from the peak (Payne-Gaposchkin 1957; Duerbeck 1981). On the other hand, spectral classification had been performed by Williams (1992).

Figure 1 is a nova map detected by the year of 2010 in galactic coordinates. Classical novae have been concentrated on the galactic plane and around the galactic center. On galactic latitude $b > 20°$ and $b < -20°$, the number of novae is at most about 8%. So the location of KT Eridani is found at a quite exceptional position ($l = 208°, b = -32°$).

KT Eri is the first classical nova detected in the constellation of Eridanus. This nova

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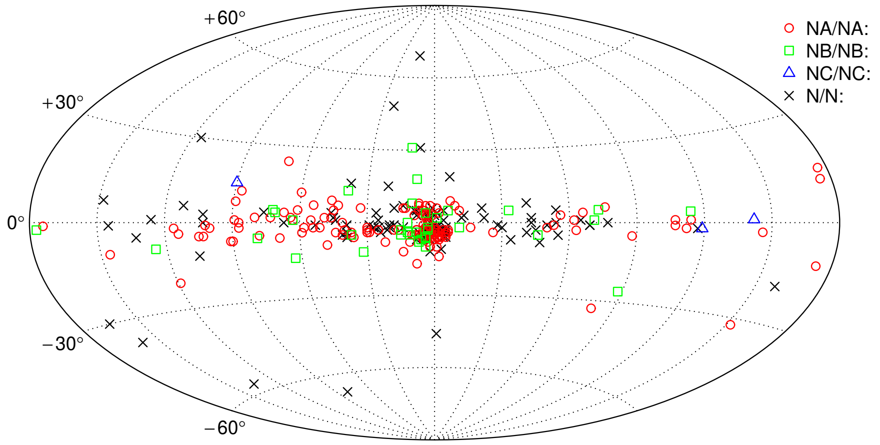

Fig. 1. The distribution of classical novae in galactic coordinates (an Aitoff projection). The data are from CV catalog (Downes et al. 2005) and IAU circulars (2006-2010 CNe).

was discovered on 2009 November 25.5 UT with 8.1 magnitude by a skillful Japanese discoverer Koichi Itagaki (Yamaoka et al. 2009). He reported the position of this object as R.A. = $4^h47^m54^s.21$, Dec. = $-10°10'43''.1$ (the equinox 2000.0). Immediately after discovery, we had started both spectroscopy and multi-color photometry at the OUS (Okayama University of Science) observatory simultaneously.

2. Observations

Our observatory is located at Okayama, which is a middle-size city of western Japan. This area is thought to be the best site in Japan for astronomical observation because of many clear nights and best seeing.

Our spectroscopic observational system is a combination of DSS-7 (SBIG production) spectrometer and ST-402 (SBIG) CCD camera installed on Celestron 28cm (F/10) Schmidt-Cassegrain telescope. Also our system of multi-color photometry is a combination of ST-7E (SBIG) CCD camera accompanied with B, V, R_c and Strömgren y filter attached to Celestron 23.5cm (F/6.3) Schmidt-Cassegrain telescope. The spectrometer's resolution $R = \lambda/\Delta\lambda$ is approximately 400 at 6000 Å, and its dispersion is 5.4 Å/pixel. Covering wavelength range is a $\lambda\lambda$4200-8300 Å.

We had performed the spectroscopic observations from 2009 November 26 to 2010 January 28. The total number of the observation is 34 nights. We also had performed the photometry from 2009 November 26 to 2010 March 19 and from 2010 August 5 to December 10. The total number is 79 nights.

3. Results

3.1. Spectroscopy

Figure 2 shows representative spectra of KT Eri. We can see the broad and prominent emission lines of Balmer series, He I, He II, N II, N III and O I in 12.2 days from maximum light. The FWHM of Hα line is 3400 kms^{-1}on the first night. According to the obtained spectra, this nova is classified as a He/N nova.

Figure 3 (left) shows a FWHM of Hα's temporal variation. It is slowed down at a rate of 30 kms^{-1}per day and diminished down to 1500 kms^{-1}about 70 days after the maximum light. Figure 3 (right) is a temporal variation of Hα profiles. It shows asymmetric profiles at the earlier stages. These suggest the existence of the non-spherical expanding gas shell.

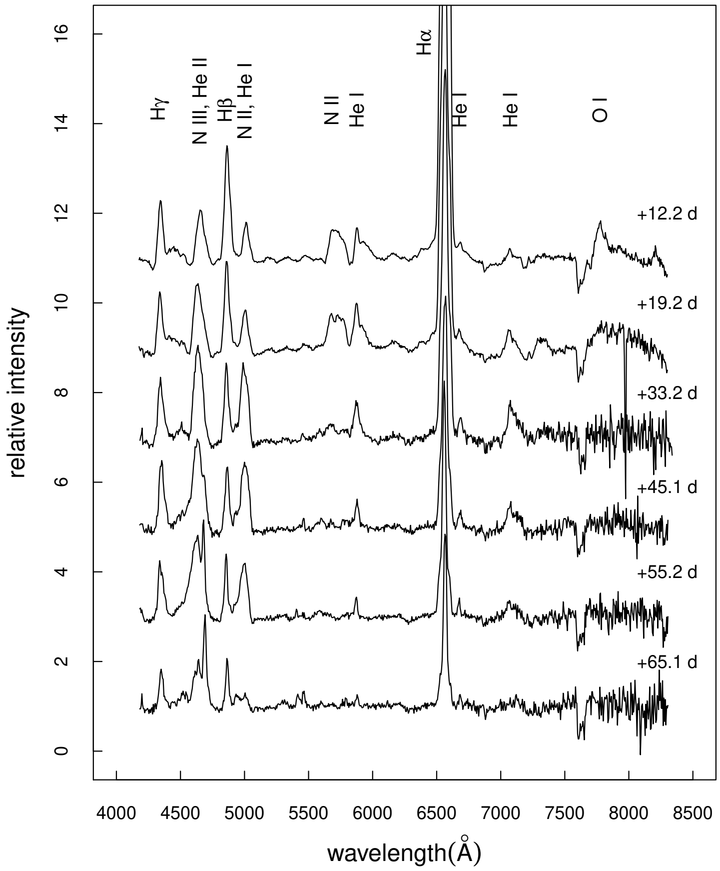

Fig. 2. Our representative spectra of KT Eri. The numerical values on the right edge are the elapsed days from the maximum light.

3.2. Multi-color photometry

Figure 4 is a result of our multi-color photometric observations. The data before the discovery are archival ones by ASAS (All Sky Automated Survey), Pi of the sky and VSOLJ (Variable Star Observers League in Japan). From these data, the maximum brightness is supposed to be 5.4 V magnitude. In its early decline phase, the magnitude change shows a rapid fading with 0.32 V magnitude per day. From of the derived parameters maximum date t_0 is 2009 November 14.4±0.2 UT. The decline time t_2 and t_3 are 6.2 ± 0.3 days and 14.3 ± 0.7 days, respectively. According to this result, the speed class is thought to be very fast.

4. Discussions

We have tried to estimate the absolute magnitude at maximum using the Maximum Magnitude Rate of Decline (MMRD) to derive the distance to KT Eri, whose color excess is $E(B - V) \sim 0.08$ (Ragan et al. 2009). Table 1 shows the results, using various parameter. Accordingly, the obtained absolute magnitude at maximum is approximately −9. The resultant distance is 6.6 ± 0.8 kpc at weight average.

Using the above results, we can discuss the spatial location of KT Eri. Taking into account that the galactic latitude of KT Eri is −32° and the distance is approximately 7 kpc, its galactic height is 4 kpc. So KT Eri is thought to be

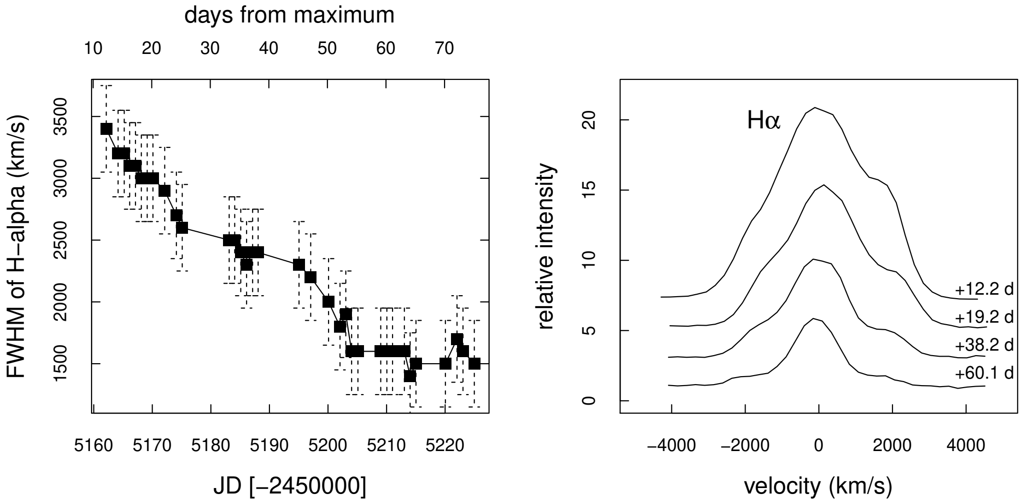

Fig. 3. The left one is FWHM of Hα's temporal variation. The right one is temporal variation of Hα profiles.

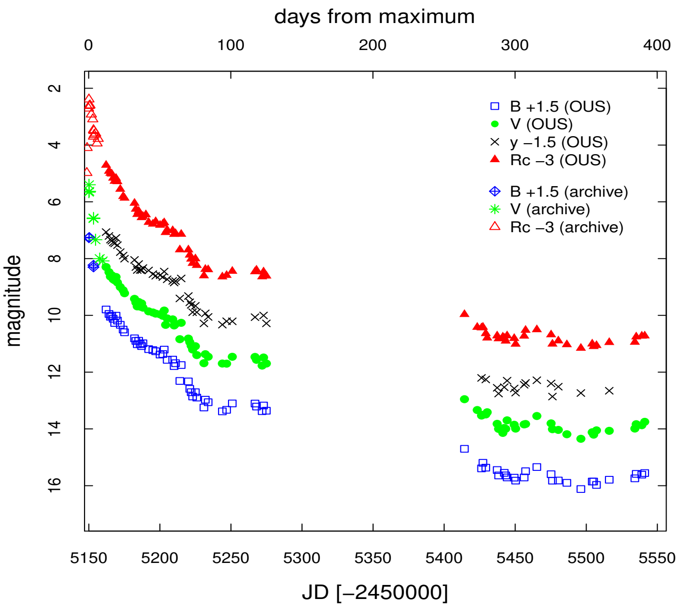

Fig. 4. The result of our multi-color photometric observations. The data before the discovery are archival ones by ASAS, Pi of the sky and VSOLJ.

outside of the galactic thick disk. If KT Eri is inside the thick disk, the apparent magnitude of maximum becomes brighter than 3 magnitude. This case is inconsistent with the observation.

The estimated distance and the apparent magnitude of possible progenitor can give the pre-nova visual absolute magnitude of KT Eri. There exist a star in the Guide Star Catalog

Table 1. Absolute magnitude at maximum of KT Eri estimated using MMRD calibrations for t_2.

MMRD	M_V	d (kpc)
(1)	−8.79 ± 0.53	6.28 ± 1.55
(2)	−8.88 ± 0.61	6.55 ± 1.87
(3)	−8.86 ± 0.41	6.49 ± 1.23
(4)	−9.30 ± 0.69	7.94 ± 2.57

Ref. (1) Cohen (1988), (2) Capaccioli et al. (1989), (3) Della Valle & Livio (1995), (4) Downes & Duerbeck (2000)

Table 2. Comparison of KT Eri with recurrent novae including giant secondary. RNe data from Warner (1987) and Schaefer (2009).

star	t_2(d)	M_V(max)	M_V(min)
T CrB	3.8	−9.3	−2.6
RS Oph	5.3	−8.7	−1.3
V394 CrA	3.3	−10	1.1
V3890 Sgr	9	−9.3	−1.1
V745 Sco	6.6	−9.5	0.8
KT Eri	6.2	−9	0.4

with about 14.8 magnitude (GSC5325.1837) at the exact position of KT Eri. If this star is its true progenitor, its absolute magnitude is approximately 0.4. Taking into account that the absolute magnitude of classical novae at minimum is 4.4 (Warner 1987), this result is much brighter by 4 magnitude. It is important to compare KT Eri with recurrent novae. Table 2 shows the properties of recurrent novae and KT Eri. KT Eri has parameters similar to that of recurrent novae. Some recurrent nova systems contain giant secondary. Therefore absolute magnitude at minimum is brighter than classical novae. If the secondary of KT Eri is a giant, its brightness in quiescence can naturally be explained.

5. Summary

1. KT Eri is an exotic nova which appeared on the high galactic latitude and opposite side from galactic center.
2. Spectral class is He/N nova.
3. Speed class is very fast nova (t_2 = 6.2±0.3, t_3 = 14.3 ± 0.7).
4. Distance is approximately 7 kpc (z ∼ 4 kpc).
5. KT Eri is located outside of the galactic disk.
6. It is plausible that secondary star is a giant.

6. Discussion

MARGARITA HERNANZ: What are the observation plan for your observatory, regarding novae?

K. TANABE: We are now going to use two types of spectrometer for single nova simultaneously. One type is the present low resolution (R∼400) and another with medium resolution (R∼2300). We also constructing an all-sky monitor for our own nova archival data accumulation.

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