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Properties of Recurrent Nova T Pyxidis Based on 2011 Outburst

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Abstract

We reexamine the properties of the recurrent nova T Pyxidis based on our own spectroscopic data accompanying with the photometric ones by VSOLJ (Variable Star Observers League in Japan) during 2011 outburst. One of the purpose of this paper is whether a missing outburst could be happen around 1988-1989. Comparing the 2011 outburst data with previous ones, we may conclude that any essential difference can not be found. Accordingly it is difficult to deny a small possibility of a "missing" outburst from 1988 to 1989, taking into account the seasonal gap in its observation for northern hemisphere observers . The problem whether IM Normae belongs to be a member of T Pyx subclass or not is to be postponed by its next outburst taking into account of T Pyx's peculiar spectral behavior.

Keywords: cataclysmic variables - recurrnt novae - T Pyxidis - optical - spectroscopy - photometry.

1 Introduction

Recurrent novae (RNe hereafter), whose definite total number is just 10 (see Warner (2008) for example), are divided into three distinct subclass, namely T Pyx subclass, U Sco subclass and T CrB subclass. Among these three, T Pyx subclass has only one member, T Pyxdis itself and has a quite unique property of very short orbital period (1.8 h). T Pyxidis is the only galactic nova belonging to the southern constellation Pyxis. Outburst of this object was discovered by H. Leavitt in 1902 photographically. This RN has experienced 5 outbursts (1902, 1920, 1944, 1966) including 1890 detected on the Harvard archival plate, before 2011 outburst. While detailed photometric observations were performed before 2011 outburst (see Schaefer (2010)), spectroscopic observations performed from early time were rather fragmentary. Moreover this RN accompanies nebulosity.

The 2011 outburst of the RN T Pyxidis was detected after 45 year of absence (twice as long as recurrence period) by Linnolt on April 14.2931(UT), 2011(Waagen(2011)). Im mediately after discovery we started low-resolution spectroscopy and obtained detailed feature of this RN before maximum light. The obtained results is reported in the paper by Imamura and Tanabe (2012). On the other hand the results of the photometric observations are based on the results performed by the members of VSOLJ (Variable Star Observers League in Japan).

In section 2, we summarize the spectroscopic observational results by Imamura and Tanabe (the present author), including both the basic properties of T Pyx obtained before 2011 outburst and the essentials of so-called Tololo classification scheme. In section 3, we try to compare the photometric observations by VSOLJ during 2011 outburst with the template light curve by Schaefer (2010) based on its previous outbursts. Then we discuss a possibility of "missing outburst" to be expected in 1988-1989 by comparing 2011 outburst with the previous ones by using the Schaefer's template light curve (Schaefer (2010)). Also we mention about the problem whether IM Normae can be another member of T Pyx subclass. At the end of this section we summarize our results.

2 Summary of Low-resolution Optical Spectroscopy

2.1 Basic properties of T Pyxidis based on pre-2011 outburst

As it is mentioned above, T Pyx is a quite unique RN for its very short orbital period (1.83 hour) compared with other RNe. Photometric behavior is characterized by slow rise and slower decline. Its position is (α,δ)=(9h04m41.47,-32deg22.0min) and (λ,β)=(150deg,-46deg). This latter ecliptic coordinate makes its seasonal gap (almost half a year) the for northern hemisphere observers. The observed spread of magnitude is B=6.4-15.4. In addition the inclination is about 10 degree (for example, Utas et al (2010)). The distance had not been known; recent value by Sokoloski(2013) is 4.8±0.5Kpc.

2.2 Spectral classification of novae

Modern and phenomenological spectral classification of Classical Novae(we denote CNe hereafter) is established by Williams (so-called Tololo classification system). According to this system, spectra of CNe are divided into two classes, namely Fe II class and He/N class. The former corresponds to slow evolution novae and the latter to fast ones. As this phenomenological scheme is thought to be a reflection of the physical stage of nova ejecta, it seems to be applicable not only to CNe but also to RNe.

2.3 Spectral evolution of T Pyxidis in its early stage of 2011 outburst

We started our low-resolution (R∼400) spectroscopy, using DSS-7 spectrograph with ST-402 CCD camera (both of them of SBIG (Santa Barbara Instrumental Group)) production attached to a 28 cm Schmidt Cassegrain telescope (Celestron production) at Tanabe's Personal Observatory(TPO) located in the north west edge of Okayama city in Japan (many photometric data obtained at TPO on dwarf novae are published by VSNET collaboration team). This site is quite suitable for astronomical observation because of its fine weather and good seeing. The Okayama Astrophysical Observatory (OAO) of National Observatory in Japan (NAOJ) is located at 40 km west from TPO.

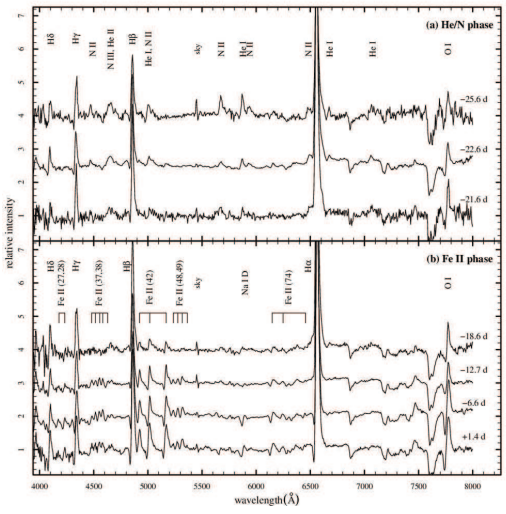

Figure 1: Spectral evolution of T Pyxidis.
Upper panel denotes earlier stage,which shows He/N feature. On the contrary lower panel is later stage that shows typical FeII spectral phase. The date after maximum light (minus means before maximum) are denoted on the right shoulder on each spectrum.

Spectral observations started at two days after discovery (April 16th and ended at 14th of May due to its position close to the sun. Total observation are 13 nights, among which 9 nights are before the maximum light. Details of the results are reported in Imamura and Tanabe (2011). Here we only summarize the peculiarity about the pre-maximum behavior that the spectral evolution is not only hybrid but opposite direction from He/N phase to Fe II one. This feature is quite exotic (see figure 1). According to the obtained P Cygni-profle, the expansion velocity turns from decreasing to increasing. Such a transition seems to cause this extraordinary evolution from He/N to Fe II phase. The relation between this evolutional feature and the temporal change of physical state as a binary system will be discussed in a separate paper.

3 Discussion

3.1 "Missing" outburst?

As is shown in figure 2, the photometric behavior of T Pyx during its 2011 outburst seems to be essentially the same as the template curve combined by previous outbursts (Schaefer (2010)). Taking into account that 45 year interval is twice as averaged interval from those 5 outburst records, we feel temptation to find out evidence of outburst around 1988-1989. In addition we can find no incompatible feature on our spectra with past fragmentary spectral data. Hence it is plausible that the structure of the T Pyx system does not change in binary structure after 45 years absence from outburst. Therefore it is worth seeking the possibility of "missing" outburst around 1988-1899. We tried to search the photometric data in VSOLJ database and found several records from the end of 1988 to 1989 with visual magnitude of 13 mag. However, unfortunately, these records were by a single observer and no distinct light variation could be seen. So this cannot be a strong evidence for missing outburst.

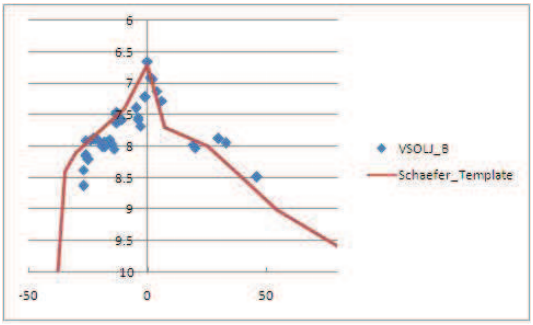

Figure 2: Light curve obtained by VSOLJ members during 2011 outburst.
Smooth curve denotes a template light curve by Schaefer (2010) based on previous photometric (B magnitude) data. We can see coincidence between two and conclude that no essential difference exist.

3.2 Is IM Normae a real member of T Pyx subclass?

Recurrent nova IM Normae is a possible member of T Pyx subclass from the point of view of light curve and its orbital period (Schaefer (2010)). However taking into account of the spectroscopic properties based on 2011 outburst, spectral evolution of T Pyx subclass is to posses such a property as the inverse change of normal transition from Fe II phase to He/N one. To confirm that IM Nor really belongs to T Pyx subclass, it is necessary for us to wait the next outburst (some 80 years) for obtaining a new data on its spectral evolution.

3.3 Conclusions

1) During the early stage of outburst, T Pyx shows the hybrid spectral transition from He/N phase to Fe II.
2) Light curve obtained by VSOLJ which seems to be identical to the Schaefer's template curve suggests the missing 1988-1989 outburst. But no strong evidence exists during these years.
3) Without spectroscopic data, the problem whether IM Normae really a member of T Pyx subclass is not settled.

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DISCUSSION

ASHLEY PAGNOTTA: There was no missed eruption in the year of 1980s.- too many observers were working.Brad Schaefer has worked at all possibble archival amateuer's data looking for trails hasn't forward anything.

KENJI TANABE: I asked recently the observer T.Kato for his 1988-1989 VSOLJ data whether the value of 13 magnitudes data indicating this RN's high state is reliable or not.His answer was of little confidence. He said that the telescope used was 20cm and visual observation at his early day of VS observations. At first I thought this was performed using 60cm telescope of Kyoto University.