Remarkable yellow supergiant variable TmzV429

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Abstract

We discovered that GSC 6554.559 is a previously unknown variable star, and named as TmzV429. We noticed that TmzV429 is identified with the IRAS-selected proto-planetary nebula (PPN), IRAS 08005-2356, which is undergoing a vigorous mass-loss episode. The analysis of photometric data suggests that TmzV429 a short-period pulsator, resembling a high-latitude yellow supergiant variable. TmzV429 is considered to be one of rare objects caught in the rapid course of PPN evolution, and shows one of the most striking mass-loss features among variable stars in the PPN stage. Since its evolutionary time-scale is estimated to be quite short (∼150 yrs), future observations of pulsations of TmzV429 is expected to provide an excellent opportunity to study the stellar evolution in real time.

1 Introduction

Proto-planetary nebulae (PPNe) are objects in transition between the AGB stage and planetary nebula (PN) stage in stellar evolution (for a review, see Hrivnak (1997)). PPNe are astrophysical objects not only important in studying the mass-loss from post-AGB stars and the formation of PNe, but also are considered to related to some of enigmatic high-latitude luminous yellow variables, such as RV Tau stars and UU Her stars (for a recent review, see Hrivnak & Lu (1997)).

TmzV429 (=GSC 6554.559) is a variable star discovered by Takamizawa (Takamizawa, 1999). The J2000.0 coordinates are 08º02‘04.71, -24º04‘42.4. Takamizawa (1999) reported small amplitude variations with a total photographic range of variability of 11.7–12.2. Takamizawa (1999) originally suspected that this star is an semiregular variable. We discovered that this variable star, inconspicuous at the time of the variability announcement, is identified with a conspicuously mass-losing central star of a PPN, IRAS 08005-2356. We describe in this paper the analysis of our photometric data and the astrophysical implications of the present identification with a rapidly evolving PPN.

2 Observations

The photographic observations by Takamizawa (Saku All Sky Survey, SASS) using 10-cm F/4.0 twin patrol cameras and T-Max400 120 emulsions. The magnitudes were determined by comparison with non-red GSC stars, whose zero-point offset from Tycho-2 V magnitudes have been estimated to be +0.5 mag. This offset is confirmed by comparison with a single point V-band CCD measurement (Kiyota, private communication). Since a constant offset does not affect the confirmation of the variability and period analysis, we use the original measurements in the following analysis. The typical error of single estimates is ∼0.2 mag, which will not affect the following discussion.

Table 1 lists all observations of TmzV429 by this observation. Figure 1 shows the overall light curve drawn from these observations.

3 Discussion

We noticed that TmzV429 is identified with the PPN with a rapid mass-loss, IRAS 08005-2356 (Slijkhuis et al., 1991). The object is also identified with an infrared source, MSX5C G242.3642+03.5822 (Egan et al., 1999).

1 The permanent designation V510 Pup has been given.
Table 1: Observations of TmzV429 by Takamizawa

| JD  | mag  | JD  | mag  | JD  | mag  | JD  | mag  |
|-----|------|-----|------|-----|------|-----|------|
| 49668.224 | 11.7 | 50125.040 | 11.8 | 50735.306 | 11.8 | 51218.037 | 11.9 |
| 49769.035 | 12.1 | 50378.328 | 11.8 | 50786.225 | 12.0 | 51272.952 | 12.0 |
| 50040.235 | 11.7 | 50426.155 | 12.2 | 50814.172 | 11.9 |
| 50074.213 | 11.7 | 50506.995 | 11.7 | 51133.285 | 12.1 |

a JD−2400000.
b Photographic magnitude. Close to V+0.5.

Figure 1: Light curve of TmzV429 drawn from the data in table 1.

The optical spectral classification by Slijkhuis et al. (1991) is a late F-supergiant with prominent hydrogen emission lines. Together with Takamizawa’s discovery of optical variability, the object seems to be classified as an high luminosity yellow supergiant variable (SRD-type in the General Catalogue of Variable Stars).

Te Lintel Hekkert et al. (1999) also reported a possible brightening by a several tenths of magnitude since 1986. This possible variation seems to be more likely attributed to shorter time-scale variations discovered by us.

We analyzed the original discovery data by Takamizawa (1999) using the Phase Dispersion Minimization (PDM) method (Stellingwerf, 1978). The result of period analysis are shown in figure 2 (left panel). The period search was done for periods between 10 and 100 d. The range was limited mainly due to the data sampling, but covers most frequently met periods in low-mass, high luminosity, SRD-type variables. The strongest period between 10 and 100 d is 28.9 d. The period probably needs be treated with caution, because the period is close to the lunar month, and because of the possible intrinsic irregularity in such a variable. A rapid fading by 0.4 mag between JD 2450378 and 2450426, however, supports the existence of short-period variation with a period less than ∼100 d.

The folded light curve by this period is shown in figure 2 (right panel). This result shows that the variability discovered by Takamizawa can be expressed by oscillations with a single, relatively short period. Although the possibility of a longer period can not be completely disregarded, the raw data (table 1) suggest a short-period variation, rather than a period of hundreds of days to years. Slijkhuis et al. (1991) reported some line features are similar to ρ Cas. The presently discovered variation, however, is not consistent with variations with a much longer period (∼300 d) as in massive ρ Cas-like variables. The star should be thereby regarded as a low-mass, post-AGB pulsator (e.g. Aikawa (1991)), which is consistent with the evolutionary stage (Slijkhuis et al., 1991) inferred from optical spectroscopy and IRAS observations.

Although the number of observations is still limited, and the present analysis unavoidably suffers from a uncertainty, the present result suggests the existence of a low-amplitude (∼0.5 mag), relatively short-period pulsations in TmzV429, which are analogous to variations observed in some stellar components of other PPNe and in high galactic luminous yellow variables, such as RV Tau stars and UU Her stars. Slijkhuis et al. (1991) suggested that the evolutionary time scale of this object is quite short (∼150 yrs). TmzV429 is thus one of
rare objects caught in the rapid course of PPN evolution, and shows one of the most striking mass-loss features among variable stars in the PPN stage. Pulsations in such stars are a sensitive indicator of the evolution [Aikawa 1991], future observations of pulsations of this object will provide an excellent opportunity to study the *stellar evolution in real time*.

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