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On the identity of Tsesevich's "YY Dra"

Taichi Kato,[1] Elena P. Pavlenko[2]

tkato@kusastro.kyoto-u.ac.jp

[1] Department of Astronomy, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan
[2] Federal State Budget Scientific Institution "Crimean Astrophysical Observatory of RAS", Nauchny, 298409, Republic of Crimea

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Abstract

Hill et al. (2022, arXiv:2203.00221) recently published analysis of the intermediate polar DO Dra (YY Dra) using TESS, ASAS-SN and ZTF data. They also attempted a search for the "lost" variable YY Dra using modern catalogs of variable stars and found no corresponding one. This search drew our renewed attention and we studied the original discovery paper of YY Dra by Tsesevich (Zessewitch). We found that two out of four variables reported by him were either lost or improperly studied. The coordinate offset from the correct position in another object was much larger than the expected error. Using the information of the published period and epoch of YY Dra, we suspect that Tsesevich used a couple of plates on which the object was invisible to derive the period rather than from a completely phased light curve. DO Dra sometimes spends high states around 14 mag for a month to several months and it would not be surprising if Tsesevich observed DO Dra in such a state and suspected it to be an Algol, urging him to examine the plate archive to obtain the moments when the variable was undetected. We suspect that Tsesevich indeed observed DO Dra, rather than a different, lost eclipsing variable. The final conclusion of this matter is almost impossible to reach due to the consequence of the World War II, destructing the large part of plate collections. Until the humanity becomes wise enough to restore this destruction and wise enough to be able to avoid further destruction of human achievements, the designation YY Dra would better be conserved as a record of our negative history and unambiguous DO Dra would better be used to designate the intermediate polar 3A 1148+719.

1 Introduction

Hill et al. (2022) recently reported on analysis of the intermediate polar DO Dra (YY Dra) using Transiting Exoplanet Surveying Satellite (TESS)[1], All-Sky Automated Survey for Supernovae (ASAS-SN) Sky Patrol data (Shappee et al. 2014; Kochanek et al. 2017), Zwicky Transient Facility (Masci et al. 2019) and other sources. The discussion about the identity of Tsesevich's "YY Dra" in Hill et al. (2022) drew our renewed attention. This object was introduced to amateur variable star observers as a rarely outbursting new dwarf nova in the mid-1980s by the American Association of Variable Stars (AAVSO), initially under the name of YY Dra and then DO Dra twice in a row using the same chart issued in their monthly circulars. Knowing this complicated history, the identity of these two designations has long been a matter of interest for many amateur observers and we would like to clarify the matter a bit.

[1] <https://tess.mit.edu/observations/>.

Original "YY Dra" was reported as one (SVS 504, Dra) of four variable stars discovered by Zessewitch (1934)[2]. The designation DO Dra was given in Kholopov et al. (1985) referring to the X-ray source 3A 1148+719 = 2A 1150+720 = PG 1140+719, following the identification of this object as a cataclysmic variable (PG 1140+719: Green et al. 1982, 3A 1148+719: Patterson et al. 1982), both giving YY Dra as the identification, and the subsequent identification as a long-period dwarf nova (Wenzel 1983a,b). In Kholopov et al. (1985), it was written as ≠YY Dra. Following this official naming of DO Dra by the General Catalogue of Variable Stars (GCVS) team, a debate arose. Patterson and Eisenman (1987) claimed that the cataclysmic variable is identical with YY Dra and the name DO Dra should be abandoned (titled as "Let's Forget DO Dra"). In response to this, the GCVS team issued "Should we Really Forget DO Dra?" (Kholopov and Samus 1988), stating: "To conclude, we do not recommend to forget DO Dra, and we do not recommend to forget YY Dra, either. If one really wants to forget something, it would be better to forget until [as written] it is *proven* that DO Dra and YY Dra are the same, or until [as written] the real YY Dra is found". Kholopov and Samus (1988) concluded: "As a group responsible for the names of variable stars we are much interested in avoiding confusion and strongly recommended to use the name DO Dra for E1140.8+7158".[3] A summary of this history was also described in Andronov et al. (2008); Babina et al. (2020).

Following this recommendation, DO Dra has been treated as the official designation of this cataclysmic variable, and it has been widely used in IAU Circulars and in the community of amateur variable star observers. The full papers by J. Patterson's group were published as Patterson et al. (1992); Patterson and Szkody (1993), clarifying the nature of this object as an intermediate polar. Patterson et al. (1992) also mentioned that there is no variable star in the vicinity corresponding to the Algol star "YY Dra".

2 New attempts

There have been attempts to search for the original Tsesevich's YY Dra considering that the published position was in error. One of the authors (TK) noticed in 2000 that the coordinates of the Algol RW UMa precessed by 50 years have the right ascension very similar to that of YY Dra with a difference in declination by 20°. Furthermore, the published epoch of the minimum of YY Dra agrees with E=−3544 of the element of RW UMa in GCVS (T. Kato, vsnet-chat 3807[4]). This finding was brought through the discussion with N. N. Samus. His message (vsnet-chat 3805[5]) might help understanding the situation, and we quote it here for reader's convenience:

> Tsessevich's observations used Simeiz plates. A part of Simeiz collection perished in the World War II, another part survived and is now in Pulkovo. The Pulkovo collection does not contain plates around the dates of minima originally announced by Tsessevich. Also, some plates could survive and be taken to Odessa, but, again, they could not be found so far.
>
> Tsessevich was a VERY experienced person and could not mix up an eclipser with a dwarf nova.

Upon the query about the possible confusion with RW UMa, Samus replied (vsnet-chat 3819[6]). We also quote it here:

> Your finding is very interesting. However, I don't believe that RW UMa and YY Dra are the same. Tsessevich told me that his star was "In a half degree" – I could not understand his remark, but now I know that his position was exactly in a half degree from the center of his plates, Z Dra"[7]. [...] As far as I remember, no other minima of YY Dra are known.

[2]The author name W. Zessewitch is the German spelling of V. Tsesevich (Цесевич, Владимир Платонович in the original language). This paper was written in English. There is also a variety of Latin transcription (Tsessevich) of his name, in which "-sse-" apparently came from the German spelling (in German, "-se-" is pronounced as "-ze-" in English, and "-sse-" was apparently used to reflect the original sound). We use the better known spelling Tsesevich, which agrees with the spelling in the original language, in the present paper when referring to the discoverer.

[3]A similar situation occurred when "GM Sgr" optically brightened and was identified with an X-ray source (Stubbings et al. 1999). The name GM Sgr had already been used to designate this variable (Goranskij 1978, 1990; Downes et al. 1995). In this case, the original GM Sgr was identified to be a different variable (see also Kato and Uemura 1999; Orosz 2000) and a new designation of V4641 Sgr was assigned (Samus et al. 1999).

[4]<http://vsnet.kusastro.kyoto-u.ac.jp/vsnet/Mail/chat3000/msg00807.html>.

[5]<http://vsnet.kusastro.kyoto-u.ac.jp/vsnet/Mail/chat3000/msg00805.html>.

[6]<http://vsnet.kusastro.kyoto-u.ac.jp/vsnet/Mail/chat3000/msg00819.html>.

[7]Since the original article would be difficult to reach, we clarify that this remark by Tsesevich was not present in Zessewitch (1934). Zessewitch (1934) only reported the position $21^{\rm h}42^{\rm m}42^{\rm s}$ +56° 15′2 (1855.0), Amplitude: 12.9–[14.5, Algol-type. Tsesevich apparently used Bonner Durchmustering to derive the coordinates.

The above explanation by N. N. Samus was partially presented as a form of private communication in Virnina (2011). There was some more details according to Samus' (1988). Samus noticed in 1983 fall [i.e. after publication by Wenzel (1983a,b)] about the bright eclipsing binary YY Dra, which had been virtually forgotten or lost and no one else had observed, while working on the 4-th Edition of the GCVS. Samus' (1988) wrote that the X-ray source 3A 1148+719 had been found in this region and that Wenzel (1983a,b) successfully identified it with an eruptive (cataclysmic in modern term) variable star. Samus' (1988) wrote that some researchers applied the name YY Dra to this cataclysmic variable, while others considered that the true YY Dra was a different star which was not be able to be recovered possibly due to the error in the position. If there had been a chart by the discoverer, the question could have been answered, but there was none in the literature. Although Samus was well familiar with Tsesevich and his knowledge in variable stars was highly evaluated, Samus was not sure whether Tsesevich remembered the position of a star which he observed long time ago. Samus discussed this matter with his colleague M. S. Frolov and Frolov immediately replied about Tsesevich's unique ability of remembrance about when and how the period varied of RR Lyr stars Frolov asked. Samus called Odessa, and Tsesevich replied that he remembered YY Dra. Here, Tsesevich replied "in a half degree" and asked to send a good plate to Odessa, on which he could mark YY Dra. A plate was quickly sent to Odessa, but Tsesevich had already been in a clinic. On October 26 he asked to bring the plate to the clinic, but after two days he passed away, bringing the mystery of YY Dra with himself.

Virnina (2011) considered that the position of the original YY Dra was in error and attempted to find an eclipsing binary in the $10^\circ \times 10^\circ$ area surrounding Z Dra by new observations. This search yielded only contact binaries, which were apparently different from the one discovered by Tsesevich.

Since all-sky photometric data such as ASAS-SN became publicly available, at least two groups independently searched the possible counterpart of Tsesevich's YY Dra: Hill et al. (2022) and Koji Mukai in the 2021 update[8] of his "The Intermediate Polars" page[9]. Mukai searched the ASAS-SN variable star database (Jayasinghe et al. 2018, 2019) matching the period in the $10^\circ \times 10^\circ$ field as in Virnina (2011) and found none. Hill et al. (2022) searched the Catalina Surveys Periodic Variable Star Catalog (Drake et al. 2014) and the ASAS-SN variable star database for the entire sky observable from Russia. There was no object compatible with Tsesevich's YY Dra even if they loosened the constraints on the amplitude and the period. Hill et al. (2022) wrote: "We cannot rule out the possibility that YY Dra really is an eclipsing binary whose position, period, and range of variation were all massively erroneous. This explanation, however, would require an unlikely confluence of errors and would probably be untestable, in that it would leave the search for YY Dra almost completely unconstrained".

3 Discussion

We here provide new perspectives regarding this matter.

3.1 Reliability of Tsesevich's classification and magnitudes

We studied three other variables discovered in Zessewitch (1934). The first object listed was YY Dra. The second one is AI Cep and was listed as a β Lyrae-type with an element of Min = 2426550.256+4.22524E. According to Albo (1964), Tsesevich discovered this object during observation of SU Cep. This ephemeris agrees with the modern one and Tsesevich apparently observed the full orbital cycle. The only small difference (0.003%) of the period from the modern one suggests that he should have used a very long (tens of years) baseline. According to Albo (1964), Tsesevich obtained this epoch for AI Cep from 296 visual observations. Another epoch of 2415615.385 was listed, which was based on two photographic observations. They were published in В. П. Цесевич, Одесса Изв. (Odessa Proceedings) 4, вып. 1 (1954). This indicates that the objects reported in Zessewitch (1934) used very heterogenous types of observations. The small number of photographic observations reported for AI Cep suggests that Tsesevich's conclusion for each object in Zessewitch (1934) was not based on a large number of plates.

The third object is NSV 14669 and the coordinates were given as $23^{\rm h}34^{\rm m}23^{\rm s}$ $+23^\circ$ $38'$ (1855.0). The object Tsesevich found is currently identified with GSC 02251-00965, which is $1'$ away from the Tsesevich's position. This object was listed as having a range of 12.5–[14.0 and was classified as Longperiodic. The ASAS-SN data show that this object is constant (T. Kato, vsnet-chat 9004[10]). and the absolute magnitude (Gaia Collaboration et al. 2021)

[8] <https://asd.gsfc.nasa.gov/Koji.Mukai/iphome/systems/yydra.html>
[9] <https://asd.gsfc.nasa.gov/Koji.Mukai/iphome/iphome.html>.
[10] <http://ooruri.kusastro.kyoto-u.ac.jp/mailarchive/vsnet-chat/9004>.

is too faint for a long-period variable. We could not find an alternative candidate in the vicinity both using variable star catalogs [The International Variable Star Index (VSX): Watson et al. (2006); Asteroid Terrestrial-impact Last Alert System (ATLAS): Heinze et al. (2018); ZTF: Ofek et al. (2020)] and 2MASS catalog (Cutri et al. 2003). This case is as problematic as YY Dra, and either variation detected by Tsesevich was an illusion or the coordinates were perfectly wrong. This case alone indicates that Tsesevich's reports were not as complete as supposed by Kholopov and Samus (1988).

The fourth object is NSV 14776 and the coordinates were given as $23^{\rm h}50^{\rm m}16^{\rm s}$ $+23^\circ$ $16'.4$ (1855.0). The object is currently identified with a Mira star NSVS J235727.2+240732 = ASAS J235727+2407.6 = ASASSN-V J235727.38+240731.3. Although the reported range and classification (11.1–[14, Longperiodic) agree with the modern one, the position is nearly $4'$ different. This difference is too large even if Tsesevich used a printed atlas of Bonner Durchmustering.

As judged from this analysis, two objects out of four in Zessewitch (1934) were either lost or misclassified, casting doubt on the reliability of Tsesevich's report.

3.2 Information from period and epoch

The large number of significant digits in the period of 4.21123 d for YY Dra would suggest that observations with a long (tens of years) baseline was used as in AI Cep. Considering that Tsesevich should have known that the duration of an Algol-type eclipse is an order of 10% of its period, he must have been aware that the reported uncertainty of the period (assuming ±5 at the end figure) corresponds to a baseline of $4.21\times0.1/0.00005$ $\simeq$8000 cycles $\simeq$90 years. This is much longer than the time (10 years) between the epoch (2419852.4) listed in the table and the date of publication. We therefore consider that Tsesevich did not make a formal analysis by creating a completely phased light curve. He probably instead used widely separated epochs of the plate on which the object was invisible and determined the unique period by finding the greatest common divisor between the intervals. This interpretation is consistent with the listed epoch corresponding to 1913 March 25, when he was at an age of 5 (Samus' 1988) and he probably spotted an old isolated exposure on which the object was invisible. This interpretation is strengthened by the given precision of the epoch: he gave the end figure only to 0.1 d in contrast to AI Cep, having a period similar to that of YY Dra, for which he gave an epoch down to 0.001 d. The given epoch indicates that it was not derived from continuous observations of an eclipse, but only conveyed the information that the plate was taken at night in Russia.

The actual intervals used by Tsesevich are difficult to estimate since we do not know at what time of nights when these plates were exposed. If he only used integer intervals (this would be a reasonable assumption, since the duration of an eclipse of a 4-d Algol is comparable to the duration of a night), an interval of $1575N$ d, where N is the integer, would be a candidate since the given period is exactly 1575/374.

As stated earlier, there would remain a possibility that he confused the element with that of RW UMa. As Samus noted, the only information from Tsesevich was that it was "in a half degree", and "a half degree from Z Dra" was an interpretation by Samus. We cannot rule out that Tsesevich meant something else and the actual variable was far from the given location.

The Algol (rather than β Lyr etc.) classification would not be inconsistent if he observed DO Dra, since the object is either visible or invisible (in outburst/high state or quiescence). As judged from the rest of objects in Zessewitch (1934), the magnitudes were unlikely too bright as suggested by Kholopov and Samus (1988). All other objects in Zessewitch (1934) have Guide Star Catalog (GSC: Lasker et al. 1990) counterparts and the limiting magnitudes should have been brighter than 15 mag. YY Dra should have been as bright. According to the DASCH light curve of DO Dra presented in Hill et al. (2022), this object was detected at intermediate brightness slightly below 14 mag in the early 1920s. Long-lasting similarly bright states were recently observed in 2017 January (V above 14.5) for a month and in 2021 May when the object was near or above V=14. Tsesevich might have observed such a long-lasting bright state when DO Dra was almost always visible on the plates he examined with occasional "invisible" moments, which could have been sufficient to convince him of the Algol-type nature and to urge him to obtain the moments in historical plates when the object was undetected.

4 Conclusion

We have shown that the results by Tsesevich were not as complete and previously supposed. In his discovery paper of YY Dra, two out of four objects were either lost or improperly studied. The coordinate offset from the correct position in another object was much larger than the expected error. Using the information of published

period and epoch of YY Dra, we suspect that Tsesevich used a couple of plates on which the object was invisible to derive the period rather than from a completely phased light curve. Judging from them, his conclusion on YY Dra was not incompatible with what is expected for the current DO Dra.

In response to Koji Mukai's judgement (typos corrected) "The main substantive point of Kholopov & Samus can be quickly dismissed. This object is not a (normal) dwarf nova; it is a Low Luminosity IP with occasional (dwarf nova-like) outbursts. If this was a normal dwarf nova, their statement might be true", we note that DO Dra pretty much behaves like a normal dwarf nova (Wenzel 1983a,b). The only apparent difference from a normal dwarf nova is the shortness (a few days) of outbursts compared to what is expected for its orbital period. If the orbital period and the nature of the secondary were unknown, the behavior of DO Dra would be indistinguishable from dwarf novae below the period gap showing only normal outbursts and high/low states in quiescence (such as IR Com). In this point, Kholopov and Samus (1988) was correct. We consider what was probably wrong with Kholopov and Samus (1988) was that they assumed that Tsesevich used a much more comprehensive data set than we suspect in this paper.

At the time of writing of this paper, crises are unfolding in Ukraine[11]. As we have seen, the final conclusion on Tsesevich's YY Dra is almost impossible to reach due to the result of the World War II. The same thing also happened in various fields of science. For example, some of type specimens in biology were completely lost (see e.g. Eggli and Leuenberger 2008; Müller and Tennent 2018). We wish that no further destruction of our treasures should occur. The illustration is the Ukrainian dove for Peace designed by Moscow-born designer Natasha Alimova to support Ukraine during the Maidan revolution of 2014. TK learned this symbol from the page by the BirdLife International[12] and I would like to share it to be with the people, including the second author with her colleagues in Ukraine and Russia, suffering from hard moments.

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List of objects in this paper

SU Cep, AI Cep, IR Com, Z Dra, YY Dra, DO Dra, RR Lyr, β Lyr, β Per, GM Sgr, V4641 Sgr, RW UMa, NSV 14669, NSV 14776, 3A 1148+719, ASAS J235727+2407.6, E 1140.8+7158, GSC 02251-00965, NSVS J235727.2+240732, PG 1140+719

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[11] <https://news.un.org/en/story/2022/02/1112952>.
[12] <https://www.birdlife.org/news/2022/02/27/why-we-stand-with-ukraine/>.

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VSOLJ
c/o Keiichi Saijo National Science Museum, Ueno-Park, Tokyo Japan

Editor Seiichiro Kiyota
e-mail: skiyotax@gmail.com