No.76 **Jul. 2021**

ISSN 0917-2211

Variable Star Bulletin

V606 Aql (Nova Aquilae 1899) is now a dwarf nova

Taichi Kato[1] and Naoto Kojiguchi[1]

[1] Department of Astronomy, Kyoto University, Sakyo-ku, Kyoto 606-8502, Japan

tkato@kusastro.kyoto-u.ac.jp

Received 2021 Jul. 15

Abstract

We found that the 1899 nova V606 Aql currently shows dwarf nova outbursts with a typical cycle length of 270 d and amplitudes of ~1.5 mag using Public Data Release of Zwicky Transient Facility observations. The low mass-transfer rate in quiescence has been suggested to explain the large eruption amplitude (Tappert et al., 2016), and the present detection of dwarf nova outbursts supports this interpretation. The transition to the dwarf nova state more than 100 yr after the nova eruption gives credence to the hibernation scenario. The absolute magnitude estimated from dwarf nova outbursts suggests that V606 Aql should have been a fast nova and the presence of high excitation lines in quiescence would be explained by the presence of a massive white dwarf.

V606 Aql is a nova discovered by W. Fleming. The nova was first seen on a plate on 1899 April 21. The early stage of the nova eruption was not well covered by observations. The brightest magnitude recorded was 6.7 (pg). The light curve showed a steep decline, followed by a plateau of 100 d duration (Duerbeck, 1987). Duerbeck (1987) extrapolated the light curve and estimated the peak of 5.5 and t_3 of 65 d.

The identification of the post-nova remained a mystery for a long period despite the bright magnitude during the nova eruption. Khatisov (1971) proposed an identification of a blend of stars. Duerbeck (1987) listed three stars composing this blend. The exact identification, however, was finally made by Tappert et al. (2016) by multicolor photometry and spectroscopy.

The post-nova had brightness of V=20.4 and R=20.1 (Tappert et al., 2016). The amplitude of the nova eruption was one of the largest among the sample of Tappert et al. (2016) and there were only ~10 novae with similar amplitudes in the sample of pre-1986 eruptions (Tappert et al., 2016). Tappert et al. (2016) discussed that these large amplitudes of eruptions may be associated with the low mass-transfer rates ($\dot{M}$) in the quiescent disk.

We used Public Data Release 6 of the Zwicky Transient Facility (ZTF, Masci et al. 2019) observations[1] and found that V606 Aql is currently in dwarf nova state (figure 1).

There were four dwarf nova outbursts between 2018 June and 2021 April (table 1). Note that ZTF g and r observations were not simultaneous. The intervals of the second, third and the fourth outbursts were 269 d and 272 d. The interval between the first and second outbursts was 484 d, suggesting that one outburst was missed between them near the solar conjunction. The relatively stable intervals between the outbursts also support the dwarf nova-type instability. The outbursts lasted for ~10 d and the fading rates were around 0.1 mag d^{-1}. Although the fading rates suggest and object with a relatively long orbital period [i.e. more than several hours, see e.g. Warner (1987); Warner (1995)], these fading rates were likely severely underestimated due

[1] The ZTF data can be obtained from IRSA <https://irsa.ipac.caltech.edu/Missions/ztf.html> using the interface <https://irsa.ipac.caltech.edu/docs/program_interface/ztf_api.html> or using a wrapper of the above IRSA API <https://github.com/MickaelRigault/ztfquery>.

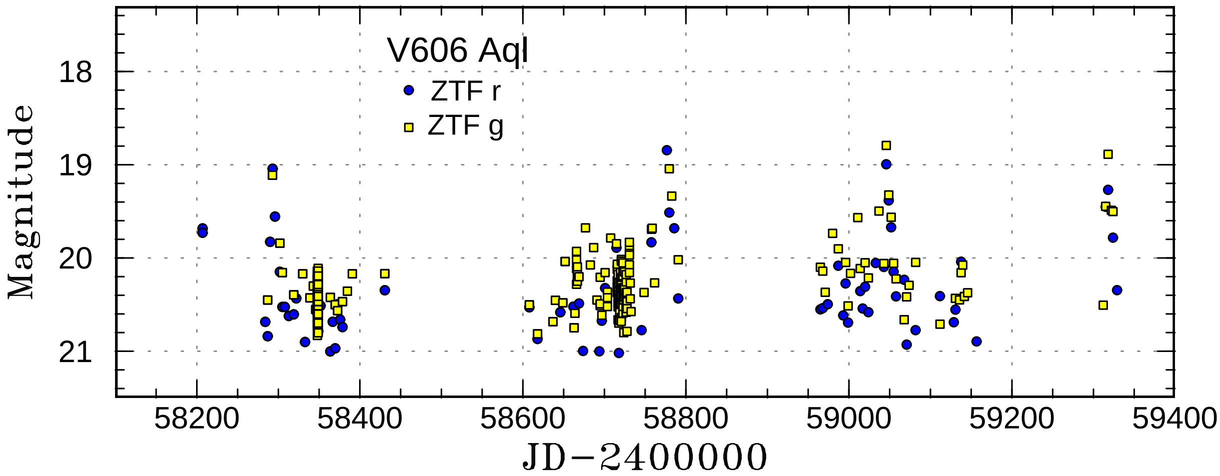

Figure 1: ZTF light curve of V606 Aql

Table 1: List of dwarf nova outbursts

Peak date	JD	ZTF g	ZTF r
2018 June 23	2458293	19.04	19.11
2019 October 20	2458777	18.84	–
2020 July 15	2459046	19.03	18.85
2021 April 13	2459318	19.27	18.89

to the contribution from the bright quiescent disk. The amplitudes of the outbursts were about 1.5 mag. ZTF made time-resolved observations on two nights on 2018 August 17 and 18 (less than 3 hr each) without detecting an eclipse.

The dwarf nova state is what is expected for a post-nova with a reduced $\dot{M}$, as suggested by Tappert et al. (2016). This finding is in line with the "hibernation" scenario (Shara et al. 1986; Patterson 1984), which suggests that $\dot{M}$ in post-novae is reduced long time (∼100 yr or more) after the nova eruption. The most recent detection of the dwarf nova activity was in the old nova BC Cas (1929) (Kato and Kojiguchi, 2020). These recent findings give credence to the hibernation scenario.

The typical absolute magnitude of outbursting dwarf novae is +4 (Warner, 1987) with a dependence on the orbital period. Since the orbital period of V606 Aql is unknown, we used +4. Using the estimated $E(B-V)$=0.35 (Tappert et al., 2016) and the standard $A(V)/E(B-V) = 3.1$, the distance modulus is estimated to be 13.8. The observed brightest magnitude of the 1899 nova eruption corresponds to $M_{\rm pg} = -8.5$ (corrected for extinction). Using the Gaia-calibrated maximum magnitude - rate of decline (MMRD) relation (Özdönmez et al., 2018), this value corresponds to a fast nova with t_3 of ∼15 d. The value appears to be consistent with the "steep decline" of the nova eruption. The presence of a plateau phase, however, may have been unusual for a fast nova. This discussion needs to be treated with caution since the true maximum was not observed and since it is unclear whether the entire disk becomes hot during these dwarf nova outbursts in post-novae.

The presence of He II and Bowen emission lines (Tappert et al., 2016) is not typical for a dwarf nova. Considering the large eruption amplitude and steep decline of the nova outburst, the mass of the white dwarf is expected to be large (e.g. Hachisu and Kato 2006). The existence of these high excitation lines may be a result of a massive white dwarf as in Kato et al. (2021).

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number 21K03616.

Based on observations obtained with the Samuel Oschin 48-inch Telescope at the Palomar Observatory as part of the Zwicky Transient Facility project. ZTF is supported by the National Science Foundation under Grant No. AST-1440341 and a collaboration including Caltech, IPAC, the Weizmann Institute for Science, the Oskar Klein Center at Stockholm University, the University of Maryland, the University of Washington, Deutsches Elektronen-Synchrotron and Humboldt University, Los Alamos National Laboratories, the TANGO Consortium of Taiwan, the University of Wisconsin at Milwaukee, and Lawrence Berkeley National Laboratories. Operations are conducted by COO, IPAC, and UW.

The ztfquery code was funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n°759194 – USNAC, PI: Rigault).

References

Duerbeck, H. W. 1987, Space Sci. Rev., 45, 1

Hachisu, I., & Kato, M. 2006, ApJS, 167, 59

Kato, T., & Kojiguchi, N. 2020, PASJ, 72, 98

Kato, T., et al. 2021, PASJ, in press (arXiv:2106.15028)

Khatisov, A. Sh. 1971, Abastumanskaya Astrofiz. Obs. Byull., 40, 13

Masci, F.-J., et al. 2019, PASP, 131, 018003

Özdönmez, A., Ege, E., Güver, T., & Ak, T. 2018, MNRAS, 476, 4162

Patterson, J. 1984, ApJS, 54, 443

Shara, M. M., Livio, M., Moffat, A. F. J., & Orio, M. 1986, ApJ, 311, 163

Tappert, C., Barria, D., Fuentes Morales, I., Vogt, N., Ederoclite, A., & Schmidtobreick, L. 2016, MNRAS, 462, 1371

Warner, B. 1987, MNRAS, 227, 23

Warner, B. 1995, Cataclysmic Variable Stars (Cambridge: Cambridge University Press)

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

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