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Double outbursts in V544 Her and ASASSN-19yt

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Abstract

In Kato et al. (2019, arXiv:1909.00910), I reported on a double outburst and rebrightenings in 2018 in V544 Her. Such a phenomenon is usually observed in WZ Sge stars which evolved after the period bounce and the colors of V544 Her in quiescence apparently exclude this possibility. Although this phenomenon was considered to be rare, I detected almost exactly the same one in 2021 using ZTF, ATLAS and ASAS-SN public data. I also detected a phenomenon very similar to this in ASASSN-19yt in 2022. The same object showed a different type of outburst in 2019 whose morphology looked like that of an SS Cyg star. If ASASSN-19yt is an SU UMa star, the morphology of the 2019 outburst would challenge our knowledge in SU UMa stars. If this object, or V544 Her, is an SS Cyg star, what causes a double outburst and rebrightenings would become an unsolved problem in dwarf novae.

Kato et al. (2019) reported a superoutburst of the SU UMa star CS Ind, which showed a long precursor outburst. The overall behavior looked like a "double outburst", which is sometimes seen in WZ Sge stars (see e.g., Kato 2015) evolved after the period bounce (Kato et al. 2013; Neustroev et al. 2017; Kimura et al. 2018).

In Kato et al. (2019), V544 Her was introduced as a dwarf nova with a double outburst and the similarity with CS Ind was discussed. Kato et al. (2019) suggested that this would be a rare phenomenon based on the absence of a similar outburst in the past data. Using Zwicky Transient Facility (ZTF: Masci et al. 2019)[1] and Asteroid Terrestrial-impact Last Alert System (ATLAS: Tonry et al. 2018) forced photometry (Shingles et al. 2021) observations, I noticed that V544 Her showed a double outburst again in 2021, contrary to the expectation in Kato et al. (2019). The overall light curve of the past eight seasons using the ZTF, ATLAS and All-Sky Automated Survey for Supernovae (ASAS-SN, Shappee et al. 2014) data is shown in figures 1 and 2. Only positive detections are shown and all other ASAS-SN observations were upper limits. There are several solitary ASAS-SN detections (such as the recent BJD 2460074 one), but they were likely noises.

The double outbursts in 2018 and 2021 are shown in detail in figures 3 and 4, respectively. They were very similar: first long outburst, dip, second long outburst and two short rebrightenings. These outbursts very much resemble the double outburst recorded in the SU UMa star CS Ind, as already reported. The red color of V544 Her [an orbital period over 0.2 d was inferred from SDSS colors (Kato et al. 2012); BP=19.59, RP=18.27 (Gaia Collaboration et al. 2022)] in quiescence, however, appears to be inconsistent with an SU UMa star with a short orbital period. All ZTF and ATLAS observations were snapshtot data and it was not possible to make a period analysis to detect possible superhumps. It looks like, however, that no large-amplitude (such as 0.2–0.3 mag) superhumps were present. Although the 2021 outburst was also detected by VSOLJ and VSNET (Kato et al. 2004) members, the detections were late during the initial long outburst and no special attention was paid since the object already appeared to be fading and since the season was too late to make long time-resolved photometry.

The first outburst in 2016 in figure 1 might have been a complex one, although the limited quality of the ASAS-SN data and still limited coverage by ATLAS made it impossible to examine it in detail. If double outbursts in this system occur relatively frequently (such as once in three years), we may have a more frequent chance to

[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>.

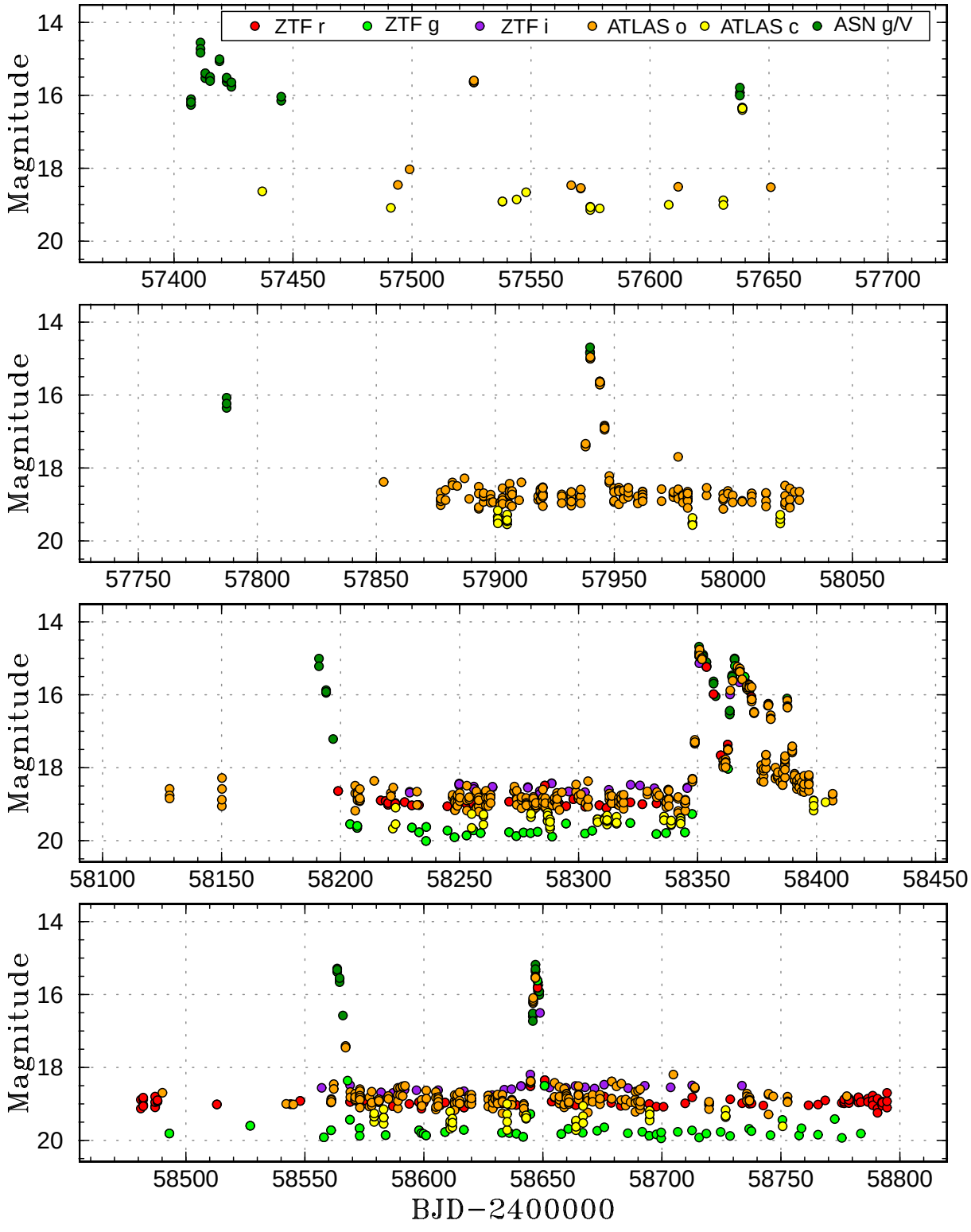

Figure 1: Light curve of V544 Her in 2016–2020. ASN refers to ASAS-SN observations. Only positive detections are shown and all other ASAS-SN observations were upper limits.

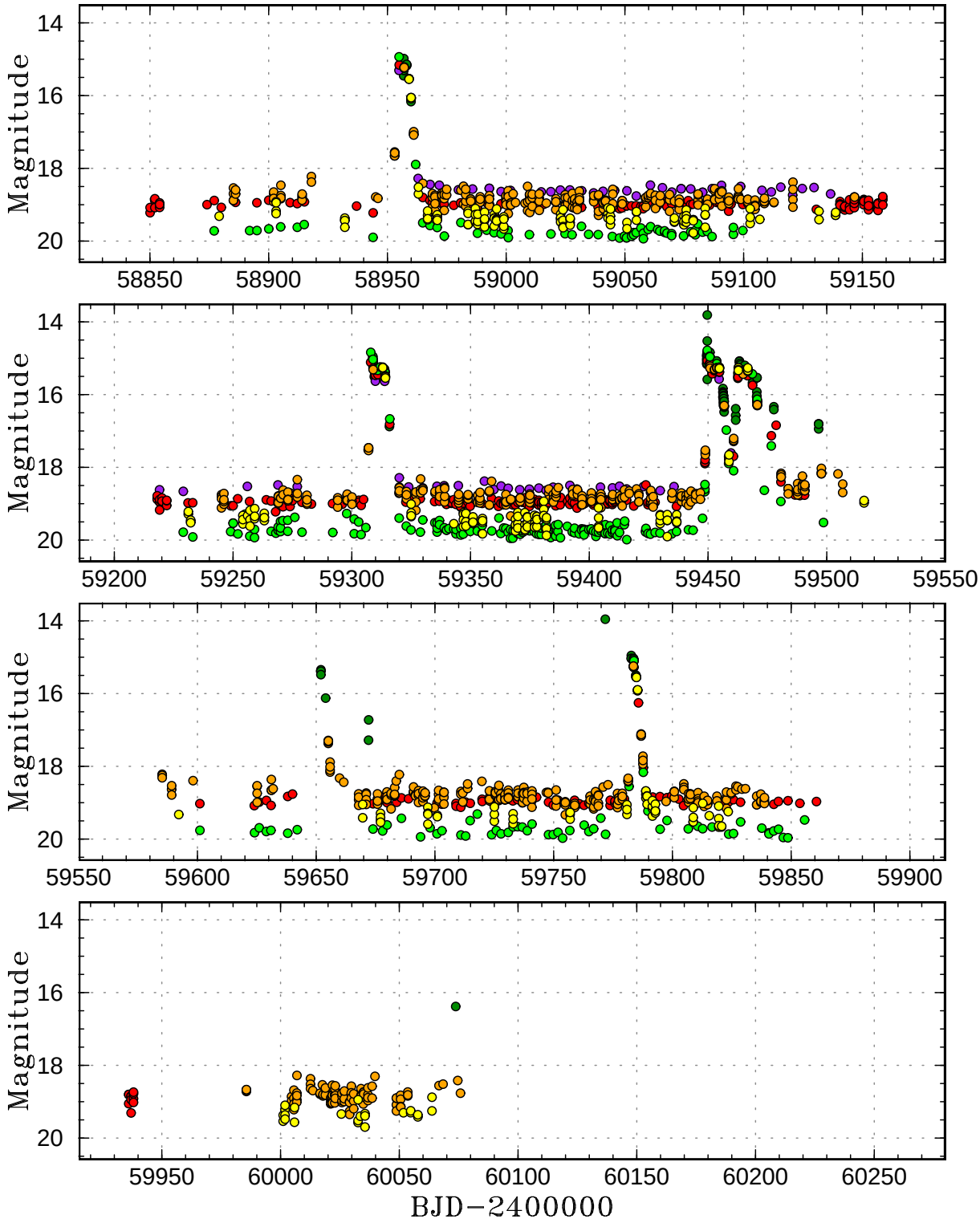

Figure 2: Light curve of V544 Her in 2020–2023. The symbols are the same as in figure 1.

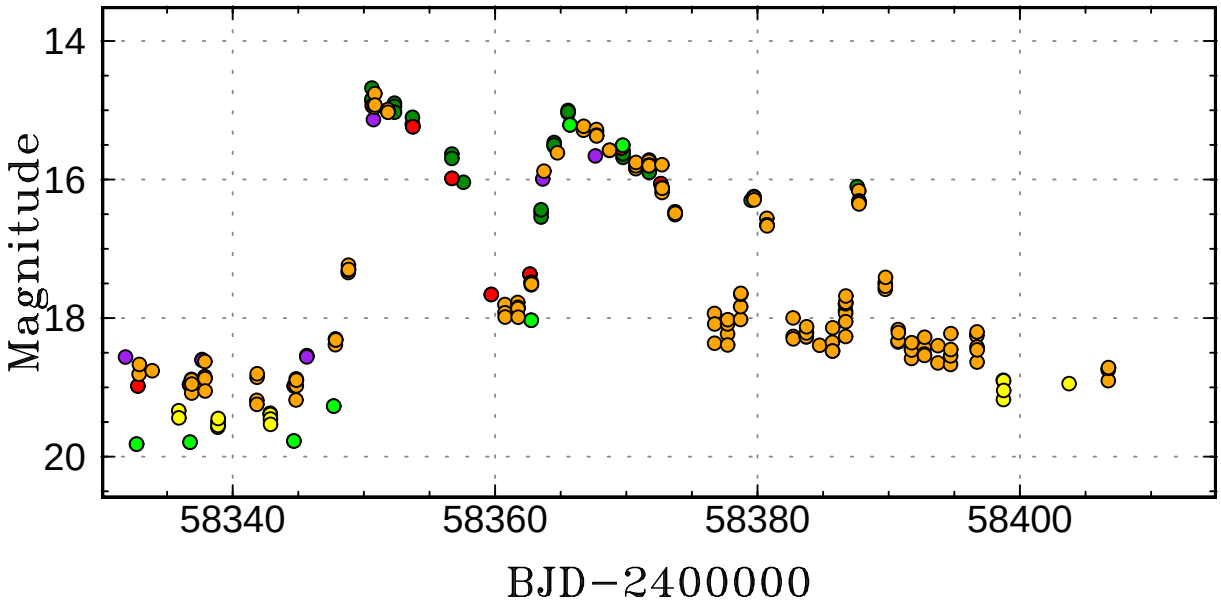

Figure 3: Double outburst and rebrightenings in V544 Her in 2018. The symbols are the same as in figure 1.

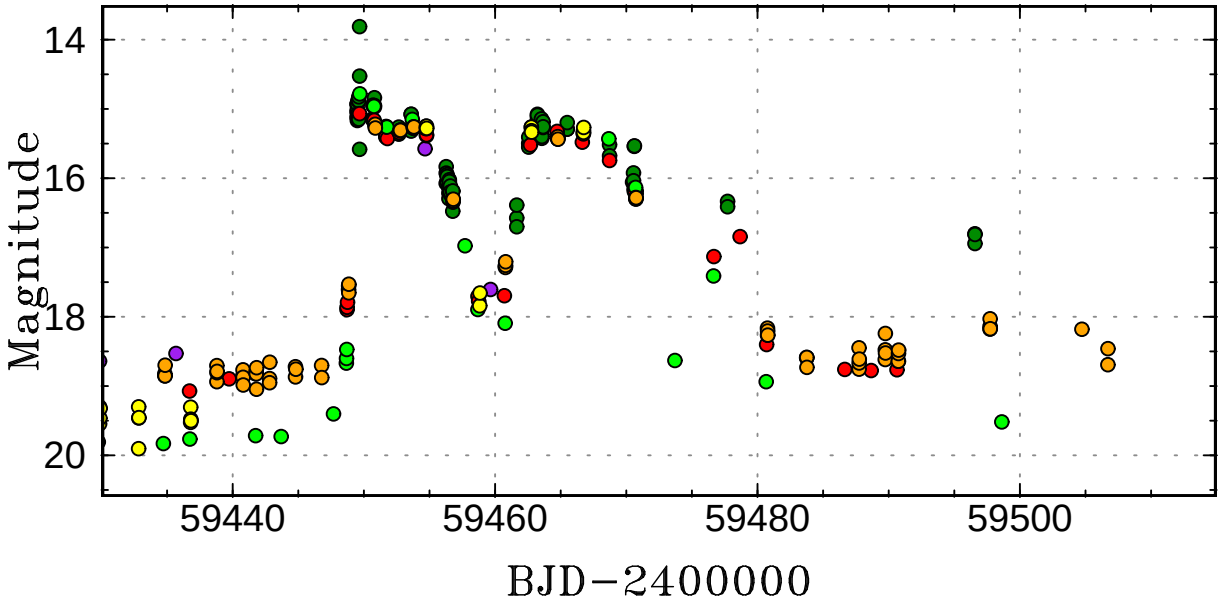

Figure 4: Double outburst and rebrightenings in V544 Her in 2021. The symbols are the same as in figure 1.

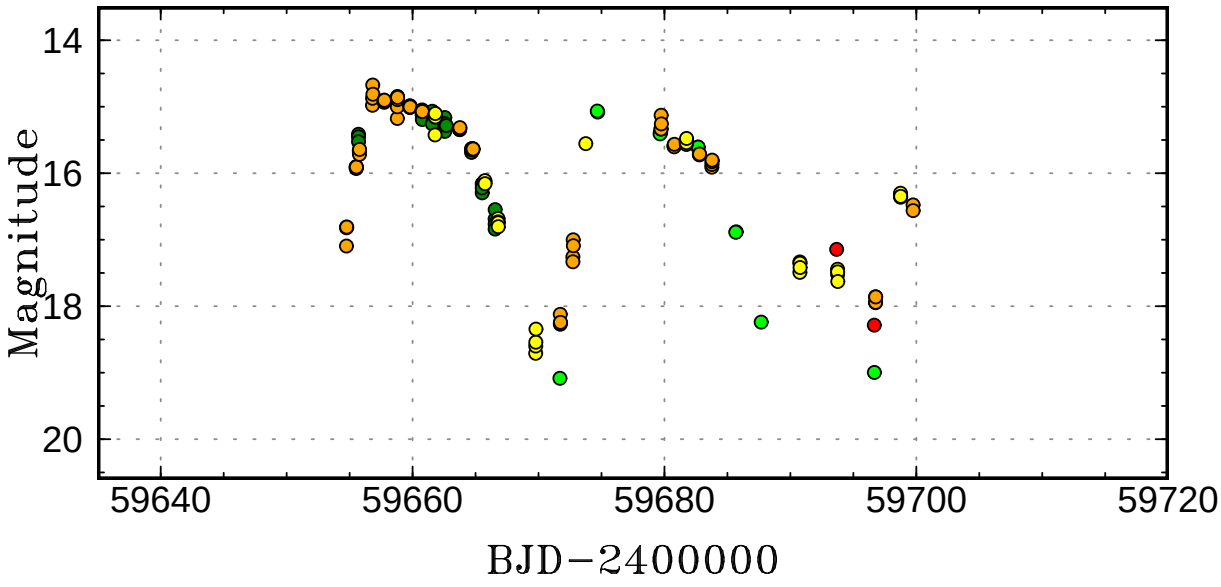

Figure 5: Double outburst and rebrightenings in ASASSN-19yt in 2022. This outburst occurred near the end of the season and ZTF did not cover the quiescence before this outburst. There were no observations after BJD 2459700. The symbols are the same as in figure 1.

determine the nature of a double outburst in this system than previously thought. There have recently been an increasing number of discoveries of SU UMa stars with long orbital periods [e.g., SDSS J094002.56+274942.0 (Kato and Vanmunster 2023); ASASSN-15cm (Kato 2023b) and BO Cet (Kato et al. 2021; Kato 2023a)] and V544 Her may join this group. It would be, however, worth noting that some outbursts in dwarf novae have yet unexplained dips, such as in MASTER OT J055845.55+391533.4 (Kato et al. 2023) and the phenomenon in V544 Her may not be related to SU UMa-type one.

I also noticed that ASASSN-19yt showed a double outburst and rebrightenings in 2022 very similar to V544 Her (figure 5). The same object showed a (relatively) long outburst in 2019 (figure 6). This outburst rose slowly and the overall symmetric shape resembled that of an SS Cyg star, although the maximum fading rate was larger than in SS Cyg stars. Tonny Vanmunster obtained a single-night run and did not detect superhumps. If this object is indeed an SU UMa star, the morphology of the 2019 outburst would challenge our knowledge in SU UMa stars, and, inversely, if this object is an SS Cyg star, what causes a double outburst and rebrightenings would become an unsolved problem in dwarf novae. Please also remember that there was also an unusual case of a long outburst and rebrihgtenings in PY Per (Kato 2022), whose nature has not yet been clarified.

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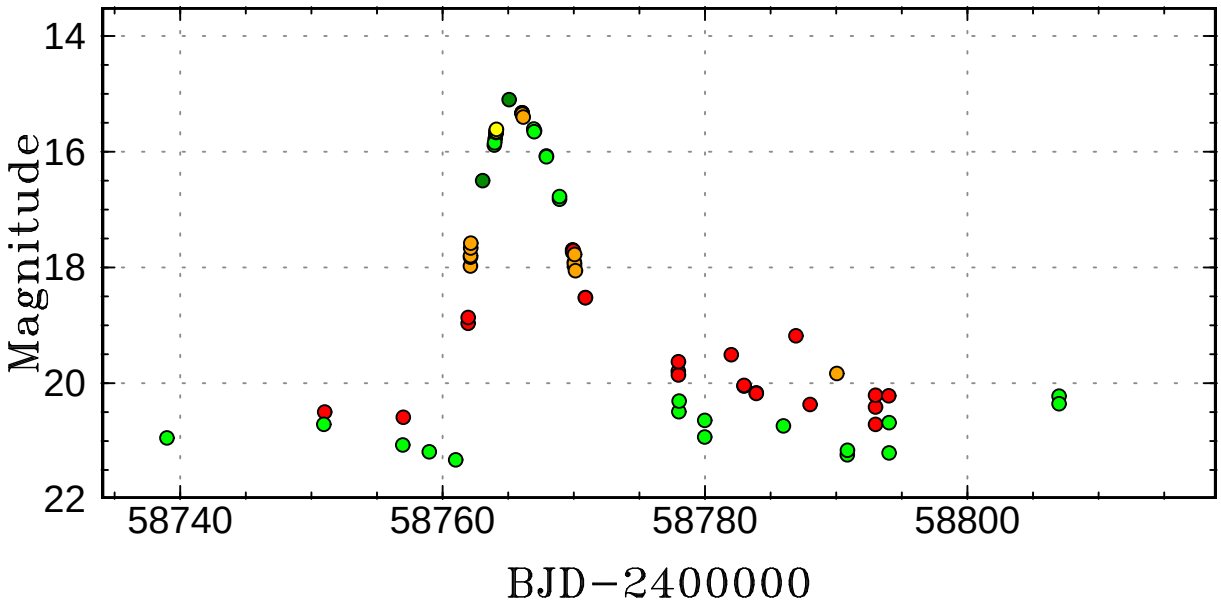

Figure 6: Long outburst in ASASSN-19yt in 2019. The symbols are the same as in figure 1.

The ATLAS project is primarily funded to search for near earth asteroids through NASA grants NN12AR55G, 80NSSC18K0284, and 80NSSC18K1575; byproducts of the NEO search include images and catalogs from the survey area. This work was partially funded by Kepler/K2 grant J1944/80NSSC19K0112 and HST GO-15889, and STFC grants ST/T000198/1 and ST/S006109/1. The ATLAS science products have been made possible through the contributions of the University of Hawaii Institute for Astronomy, the Queen's University Belfast, the Space Telescope Science Institute, the South African Astronomical Observatory, and The Millennium Institute of Astrophysics (MAS), Chile.

List of objects in this paper

BO Cet, SS Cyg, V544 Her, CS Ind, PY Per, SU UMa, WZ Sge, ASASSN-15cm, ASASSN-19yt, MASTER OT J055845.55+391533.4

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