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Long-lasting standstill and fading episode in the IW And star V507 Cyg

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Abstract

We studied the IW And star V507 Cyg using ASAS-SN data, ZTF data and our snapshot photometry. The star has been found to be in a long standstill in 2020 May–2022 March (and it still continues now). Such long-lasting standstills have been found in a few other IW And stars in the past literature. We found that this system was systematically fainter by 0.3 mag between 2018 March and 2019 January when it showed dwarf nova-type variations, including IW And-type states. This is one of the clearest pieces of evidence that the dwarf nova-type state in Z Cam stars (in a broader sense) is associated with a decrease in the mass-transfer rate (∼25% for a duration of 300 d in this case). The object also showed IW And-type phenomena in 2019, when the system was as bright as in the current long standstill. This finding suggests that the condition whether the IW And-type phenomenon occurs or not is subtle under the same mass-transfer rate.

V507 Cyg is one of the prototypical IW And-type stars (for references of IW And stars, see Simonsen 2011; Szkody et al. 2013; Hameury and Lasota 2014; Kato 2019). We report on the detection of a long standstill in 2020 May–2022 March. We used observations by the All-Sky Automated Survey for Supernovae (ASAS-SN) Sky Patrol data (Shappee et al. 2014; Kochanek et al. 2017), the Zwicky Transient Facility (ZTF: Masci et al. 2019) data[1] and unfiltered snapshot CCD observations by one of the authors (MM).

When Kato (2019) initially reported on this object, this object primarily showed dwarf nova-type variations sometimes interrupted by short standstills, which had characteristics of IW And stars as follows: (1) Standstills were terminated by brightening. (2) There were quasi-periodic cycles consisting of a (quasi-)standstill with damping oscillations — brightening which terminates the standstill — a deep dip and returning to a (quasi-)standstill (see figure 1 around BJD 2457950–2458040 and BJD 2458275–2458330). After this IW And-type state, which was followed by an ordinary dwarf nova state (at the end of figure 1 and the beginning of figure 2), long standstills appeared, which were interrupted by brightening (BJD 2458675, 2458783 and 2458836) followed by a dip and subsequent damping oscillations, which are characteristic to an IW And-type object. After BJD 2458990 (2020 May), this object entered a long-lasting standstill, which has continued up to now (figure 2). It would be interesting to note that the standstill BJD 2458890–2458950 was terminated by fading as in usual Z Cam stars.

Such long-lasting standstills had been recorded in IM Eri (Kato et al. 2020), BO Cet (Kato et al. 2021) and ASAS J071404+7004.3 (Kato et al. 2022): all these objects were initially considered as novalike stars because of this (Chen et al. 2001; Armstrong et al. 2013; Rodríguez-Gil et al. 2007; Inight et al. 2022). A similar IW And-type object HO Pup (Kimura et al. 2020; Lee et al. 2021), however, did not show such a long standstill lasting for a year.

[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>.

We analyzed the the trend of mean magnitudes (averaged in flux) as we performed for two IW And stars ST Cha (Kato and Kojiguchi 2021) and ASAS J071404+7004.3 (Kato et al. 2022) using locally-weighted polynomial regression (LOWESS: Cleveland 1979). The result is shown in figure 3. We should note that the trend before BJD 2458000 was overestimated (brighter than actual) when the ASAS-SN observations were not deep enough to record the object at minimum brightness. The trend after BJD 2458000 can be considered as real.

It is apparent that the object was systematically fainter by 0.3 mag between BJD 2458200 and 2458500, when the object showed dwarf nova-type variations including the IW And-type states. Although it is widely believed that standstills in Z Cam stars reflect the states with higher mass-transfer rates (Meyer and Meyer-Hofmeister 1983), the results by observations have not been very clear (Honeycutt et al. 1998; Kato et al. 2019; Kato 2021; Kato et al. 2022). The present case provides the first clear evidence that a dwarf nova-type phase (including the IW And state) was associated with a fading episode by 0.3 mag (corresponding to a 25% decrease in the mass-transfer rate) lasting for $\sim$300 d. The 2019 state with standstills interrupted by brightening followed by damping oscillations (BJD 2458560–2458860) was as bright as the following long standstill. This implies that occasional IW And-type phenomena also occurred at the same mass-transfer rate as in the long standstill and that the condition whether IW And-type phenomena occur or not is subtle.

Corrections

While working on this object, TK noticed that there were scaling errors in ST Cha (Kato and Kojiguchi 2021) and ASAS J071404+7004.3 (Kato et al. 2022). I here present the corrected figures 4 and 5.

Acknowledgements

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List of objects in this paper

IW And, Z Cam, BO Cet, ST Cha, V507 Cyg, IM Eri, HO Pup, ASAS J071404+7004.3

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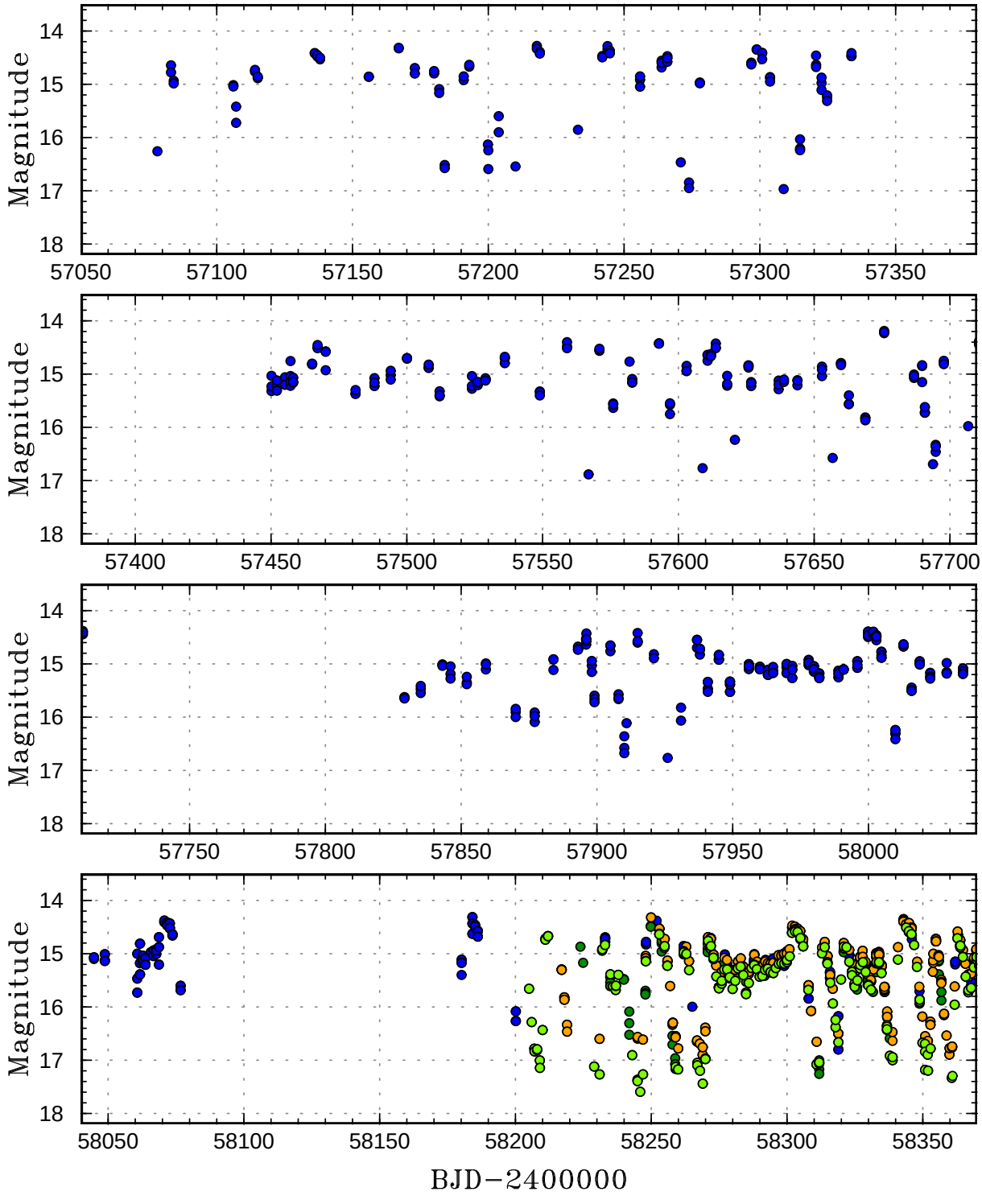

Figure 1: Long-term light curve of V507 Cyg using ASAS-SN and ZTF observations. See figure 2 for the symbols. V507 Cyg primarily showed dwarf nova-type variations sometimes interrupted by short standstills bearing characteristics of IW And stars. This figure corresponds to figure 2 in Kato (2019) with subsequent observations.

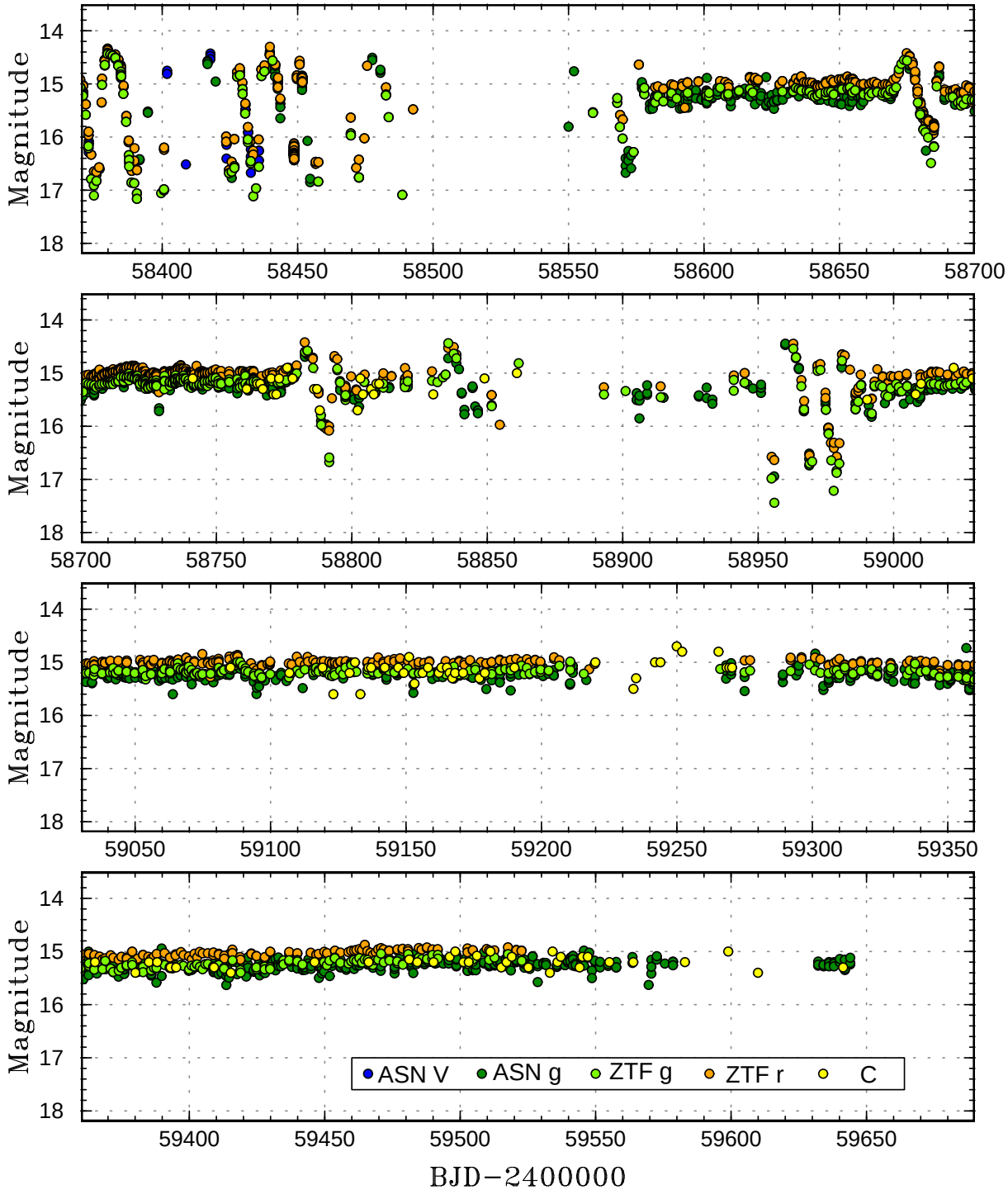

Figure 2: Long-term light curve of V507 Cyg using ASAS-SN, ZTF and our unfiltered CCD observations (C). ASN in the legend stands for ASAS-SN. This figure is the continuation of figure 1. V507 Cyg initially showed dwarf nova-type variations. Long standstills then appeared (BJD 2458580), which were interrupted by brightening followed by a dip and subsequent damping oscillations. After BJD 2458990, this object entered a long-lasting standstill, which has continued up to now.

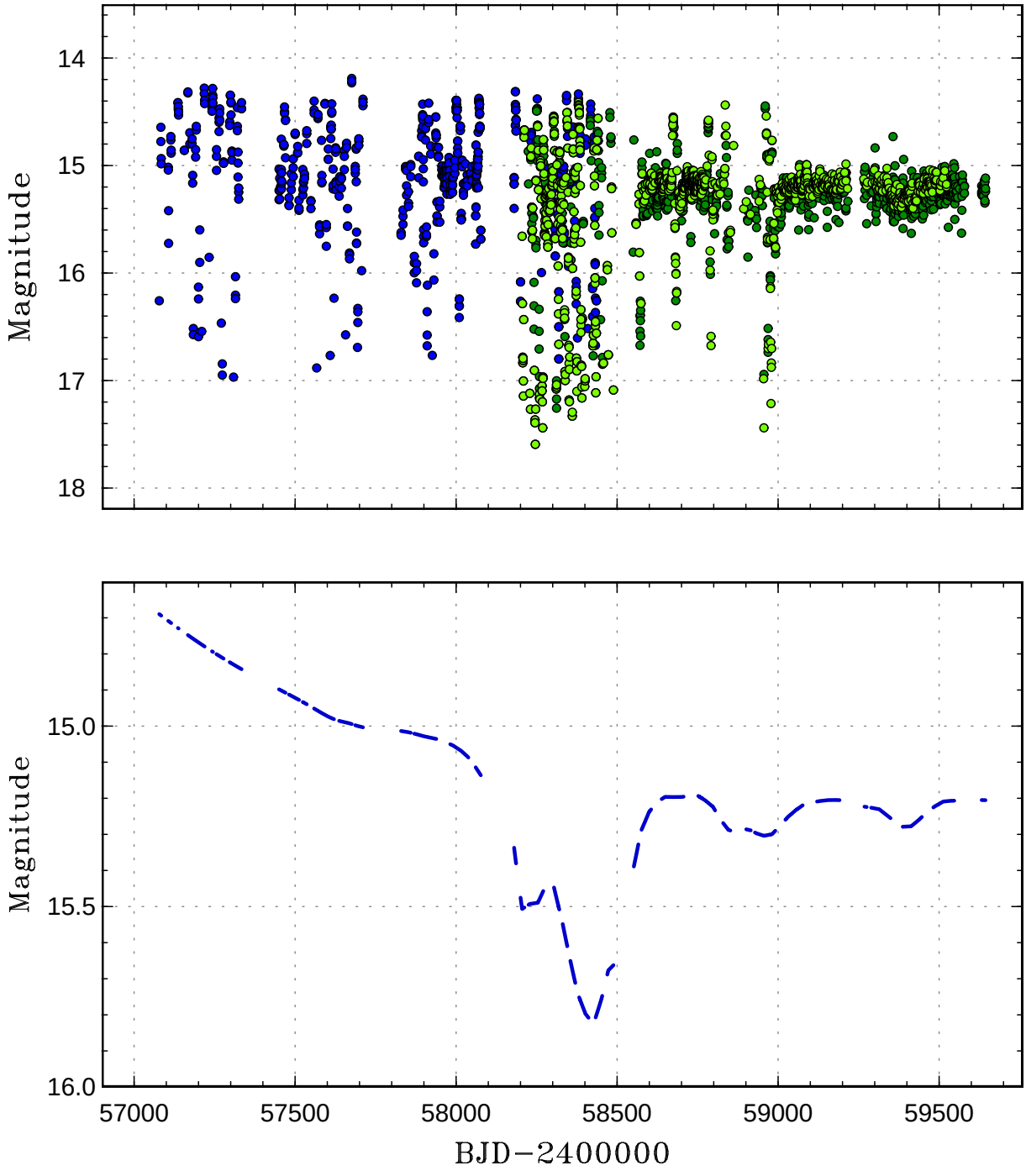

Figure 3: (Upper): Combined ASAS-SN and ZTF g light curve of V507 Cyg. See figure 2 for the symbols. (Lower): Trend determined by LOWESS. A smoothing parameter of f=0.20 was used. The dwarf nova state (including the IW And-type state) in 2018 (BJD 2458200–2458500) corresponded to a state fainter than the subsequent state by 0.3 mag in average. Note that the trend is overestimated (brighter than real) before BJD 2458000.

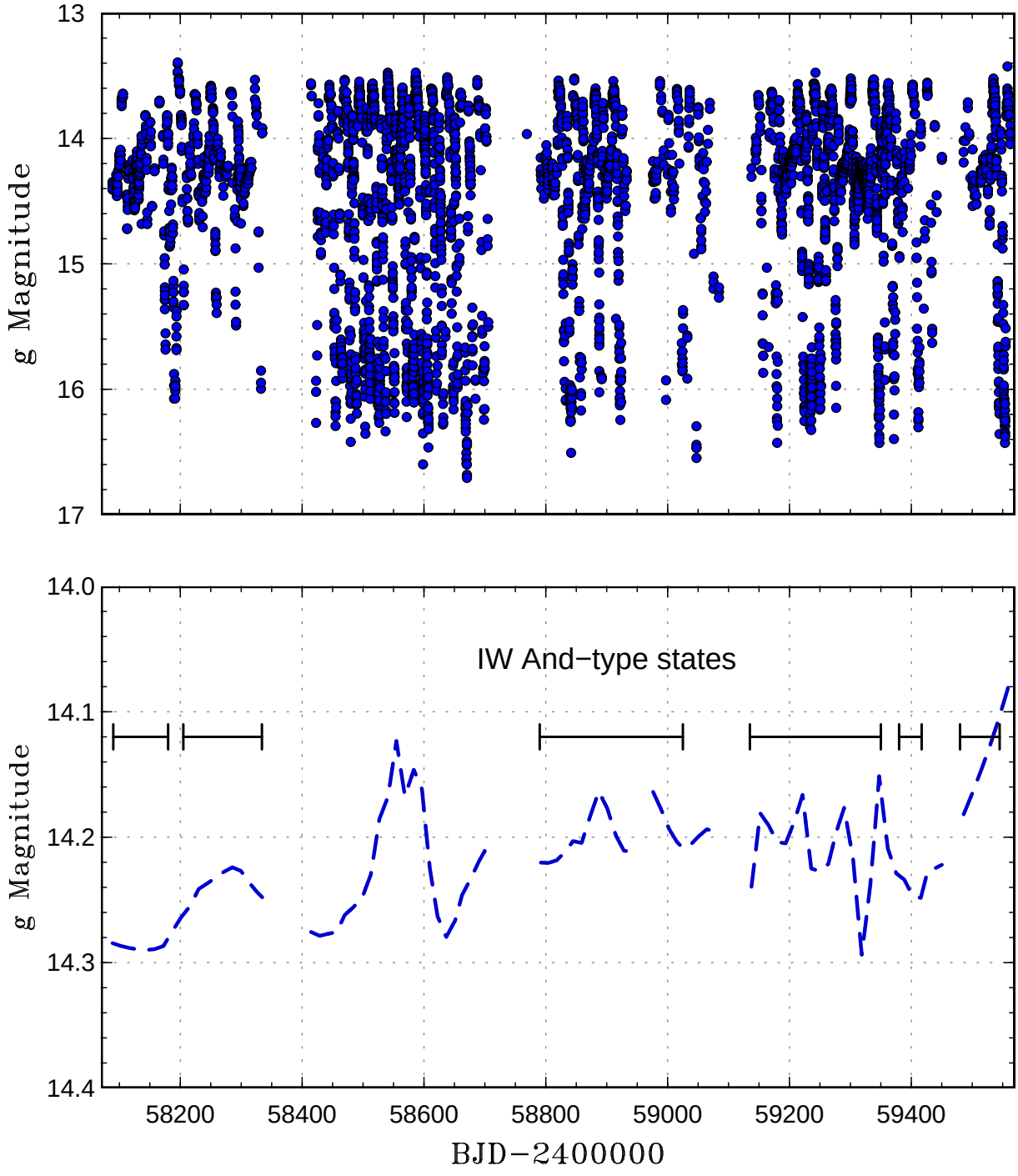

Figure 4: (Upper): ASAS-SN g-band light curve of ST Cha. (Lower): Trends determined by LOWESS. Horizontal marks represent IW And-type states. (Correction of Kato and Kojiguchi 2021)

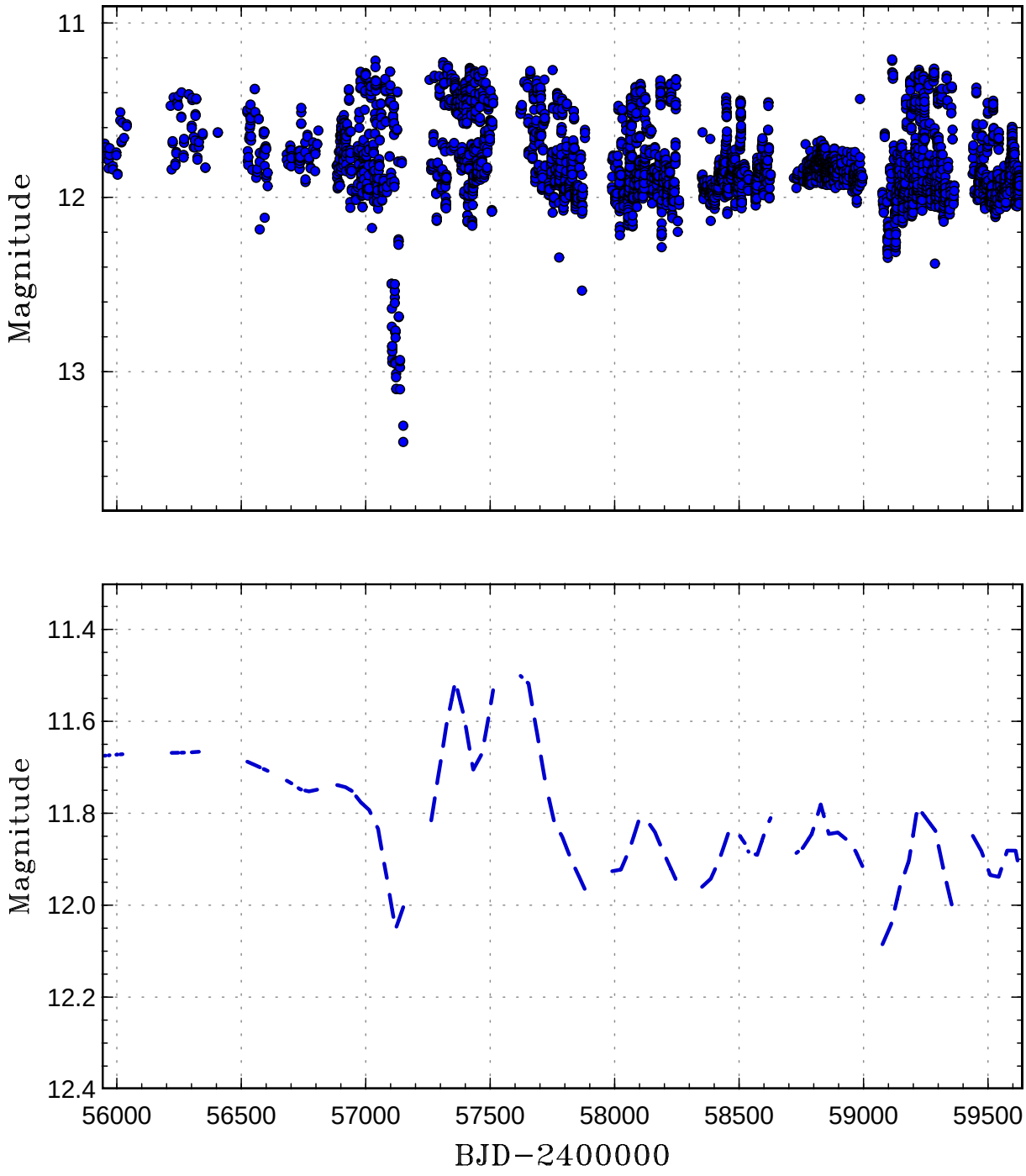

Figure 5: (Upper): ASAS-SN light curve of ASAS J071404+7004.3. (Lower): Trend determined by LOWESS. A smoothing parameter of f=0.05 was used. (Correction of Kato et al. 2022)

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