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ASASSN-V J205543.90+240033.5: another white dwarf pulsar?

Taichi Kato[1]

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

tkato@kusastro.kyoto-u.ac.jp

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Abstract

I found that ASASSN-V J205543.90+240033.5 shows large-amplitude (1.2–1.4 mag) nearly sinusoidal variations with a period of 10.803(2) d and very short period variations with a period of 0.0068 d using Public Data Release of Zwicky Transient Facility observations. The only known object that shows a similar combination of nearly sinusoidal reflection variations and very short period, large-amplitude variations is the unique white dwarf pulsar AR Sco. ASASSN-V J205543.90+240033.5 appears to be very similar to AR Sco and observations at various wavelengths are desired.

ASASSN-V J205543.90+240033.5 is variable object detected by the All-Sky Automated Survey for Supernovae (ASAS-SN, Shappee et al. 2014, Kochanek et al. 2017) and was cataloged as and eclipsing binary (type EB) with a period of 1.046984 d.[1] This object was also independently listed as a candidate RR Lyr star by Sesar et al. (2017) using the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS1, Chambers et al. 2016). It was also independently listed as a variable star ATO J313.9329+24.0092 by Heinze et al. (2018) using the Asteroid Terrestrial-impact Last Alert System (ATLAS, Tonry et al. 2018) data.

I used Public Data Release 6 of the Zwicky Transient Facility (Masci et al., 2019) observations[2] and found that this object showed large-amplitude (1.2–1.4 mag) nearly sinusoidal variations with a period of 10.803(2) d and very short period variations during time-resolved runs on two nights in the ZTF data (figures 1, 2).

The object is very blue as can be seen as the almost zero color index in figures 1, 2. The large distance modulus (11.1 mag) based on the Gaia parallax (Gaia Collaboration et al., 2021) indicates that the object is intrinsically faint. These features suggest that this 10.803-d day variation is caused by reflection by the secondary star in a binary containing a hot component.

The short-term variations are directly visible to the eye in the ZTF time-resolved photometry (figure 3). Phase Dispersion Minimization (PDM; Stellingwerf 1978) analysis after de-trending the data yielded periods of 0.00675(3) d for the BJD 2458661 run (figure 4) and 0.00682(2) d for the BJD 2458802 run (figure 5). The errors of the periods were determined by the methods of Fernie (1989) and Kato et al. (2010). These periods are fairly in agreement and I consider that they represent the spin period of the white dwarf.

This combination of the large-amplitude reflection variation and the high-amplitude spin pulse is seen in the white dwarf pulsar AR Sco (Marsh et al. 2016; Stiller et al. 2018). We recently reported that ZTF J185139.81+171430.3 = ZTF18abnbzvx shows high-amplitude spin variations (Kato and Kojiguchi, 2021) and suggested it to be a possible white dwarf pulsar, but the large-amplitude reflection variation is missing in ZTF J185139.81+171430.3. The present observations indicate ASASSN-V J205543.90+240033.5 looks more similar to AR Sco than ZTF J185139.81+171430.3 and observations in various wavelengths to search for the evidence for non-thermal emissions as in AR Sco.

[1] Variable Stars Database (AVSD) <http://asas-sn.osu.edu/variables> on 23-Oct-2020) (22-Oct-2019 version).

[2] 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>.

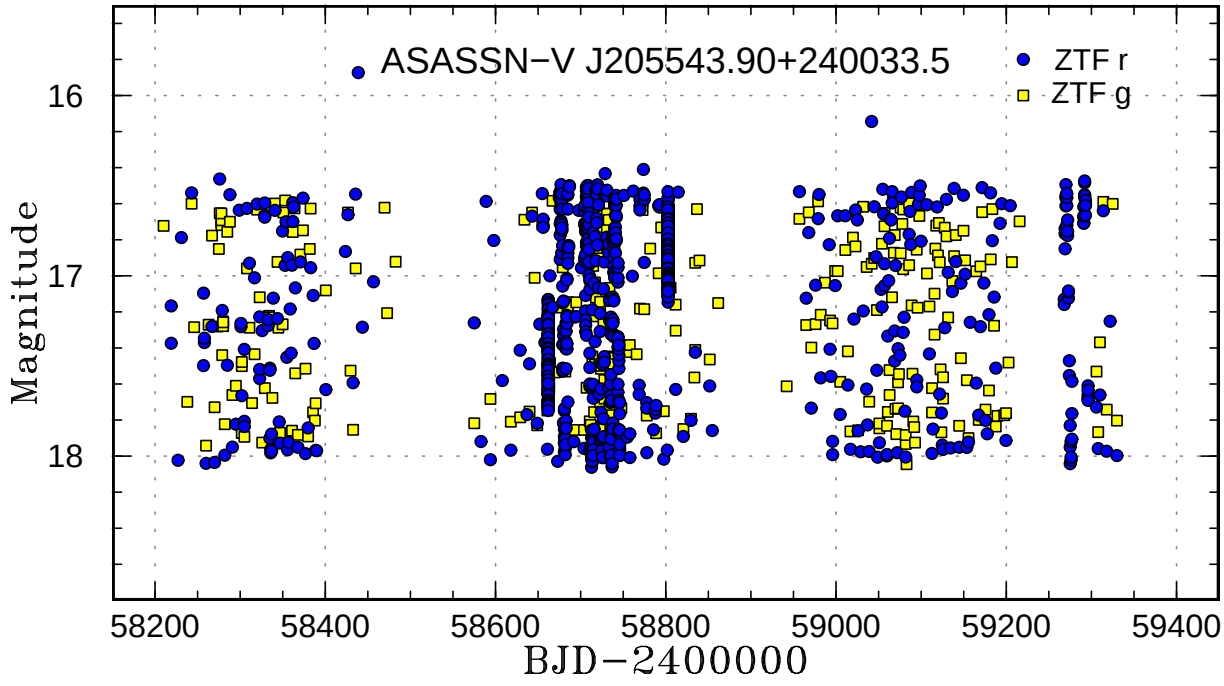

Figure 1: Long-term variations of ASASSN-V J205543.90+240033.5 in the ZTF data.

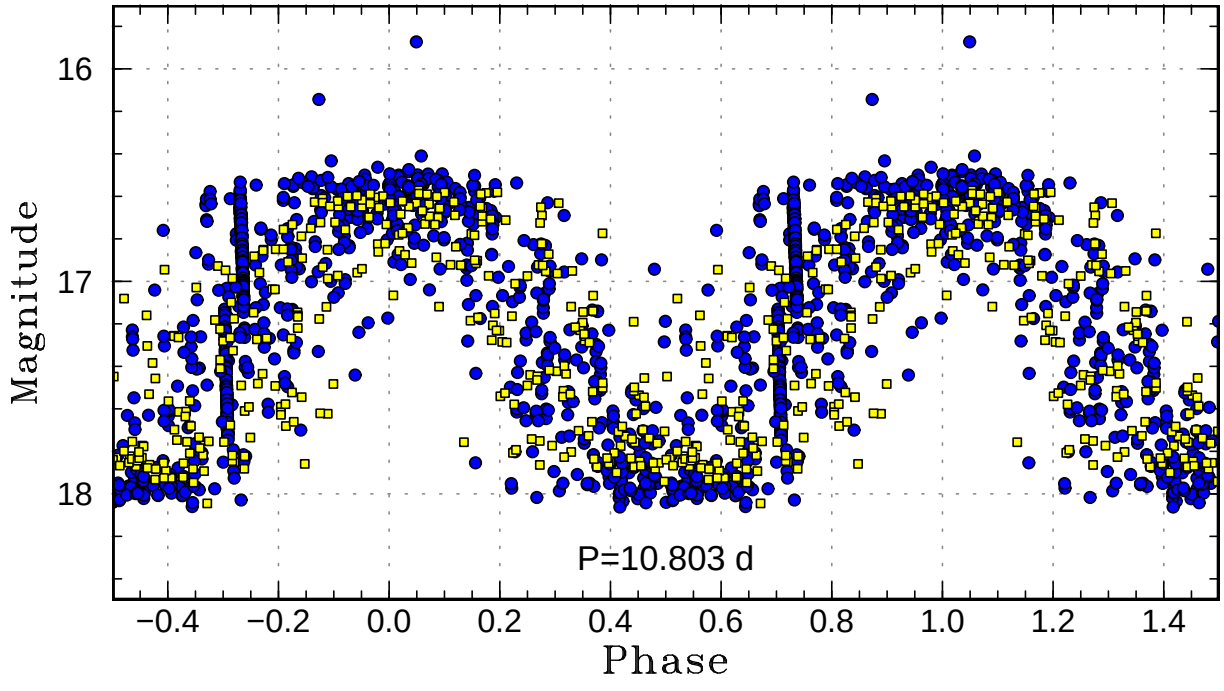

Figure 2: Phase-folded variations of ASASSN-V J205543.90+240033.5 in the ZTF data. The symbols are the same as in figure 1. The epoch was chosen as BJD 2458773.10.

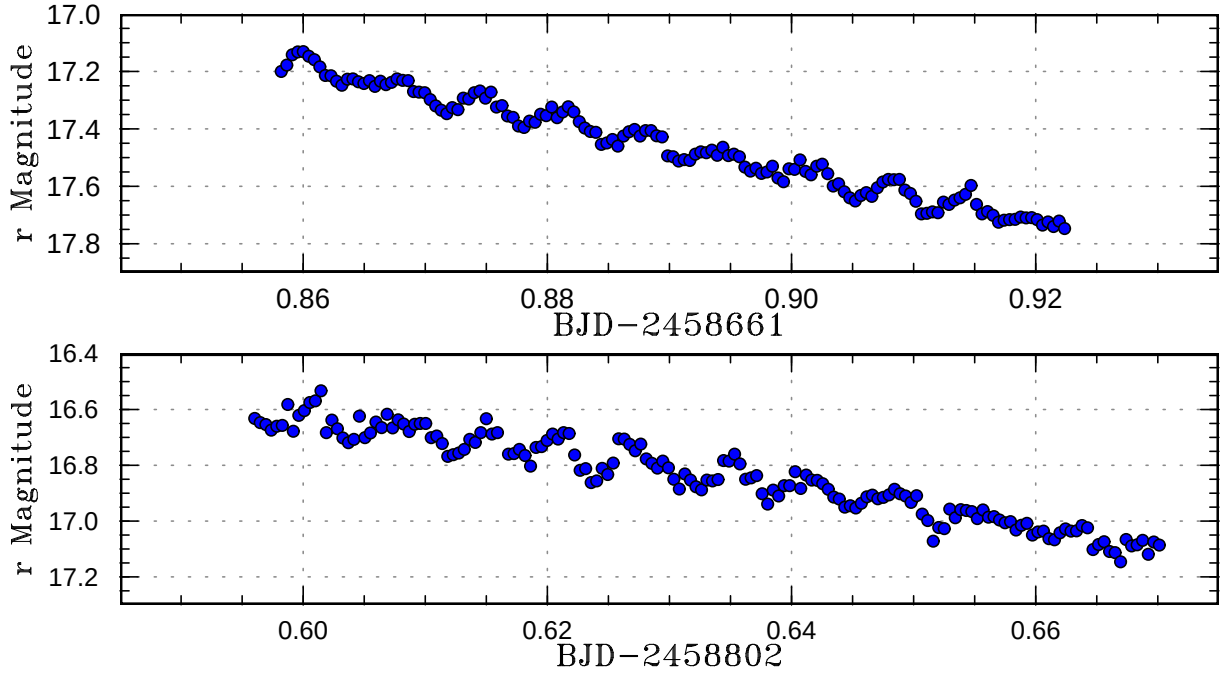

Figure 3: Short-term variations of ASASSN-V J205543.90+240033.5 in the ZTF data.

Acknowledgments

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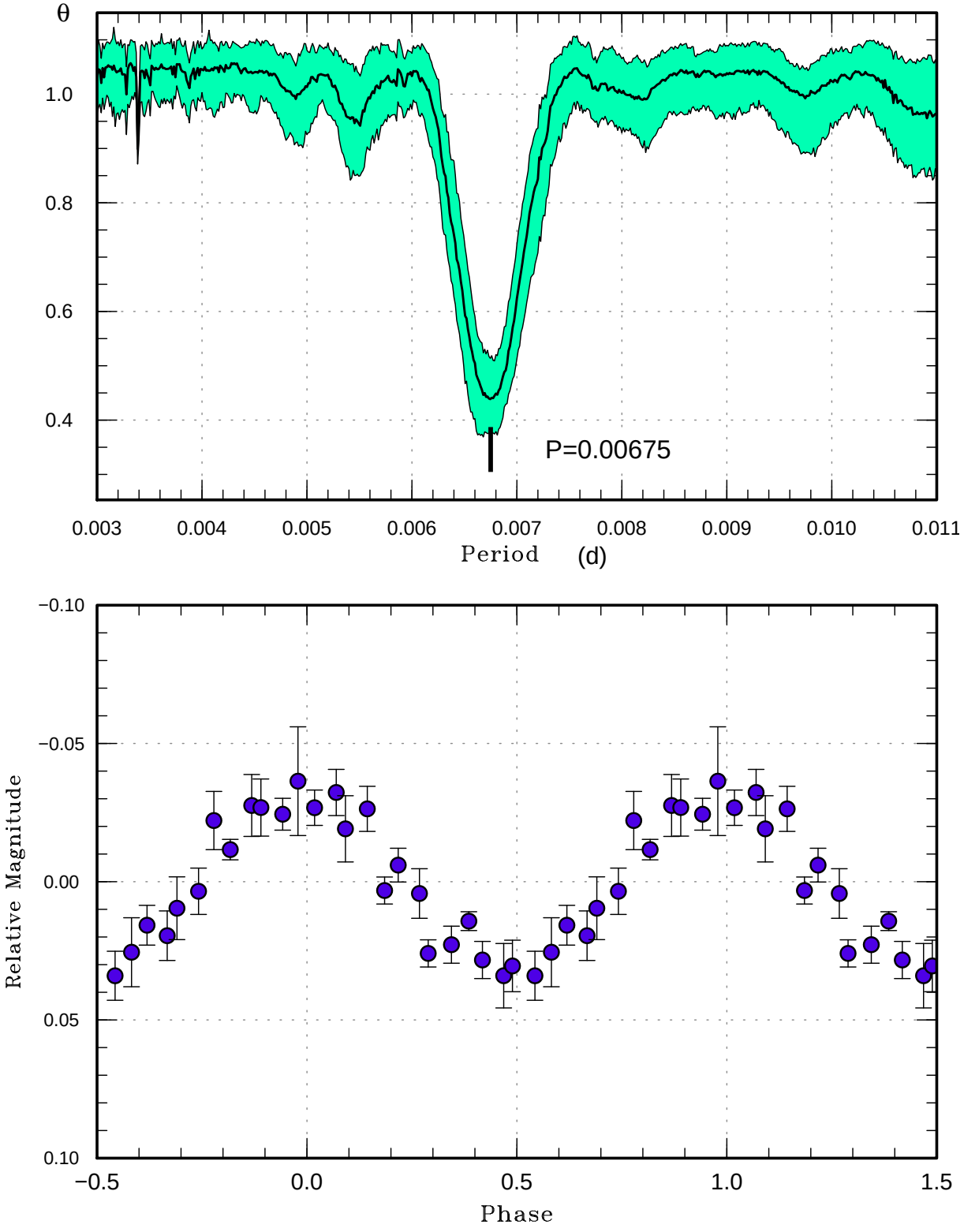

Figure 4: Pulse profile of ASASSN-V J205543.90+240033.5 on BJD 2458661. (Upper): PDM analysis. We analyzed 100 samples which randomly contain 50% of observations, and performed the PDM analysis for these samples. The bootstrap result is shown as a form of 90% confidence intervals in the resultant PDM θ statistics. (Lower): Phase-averaged profile.

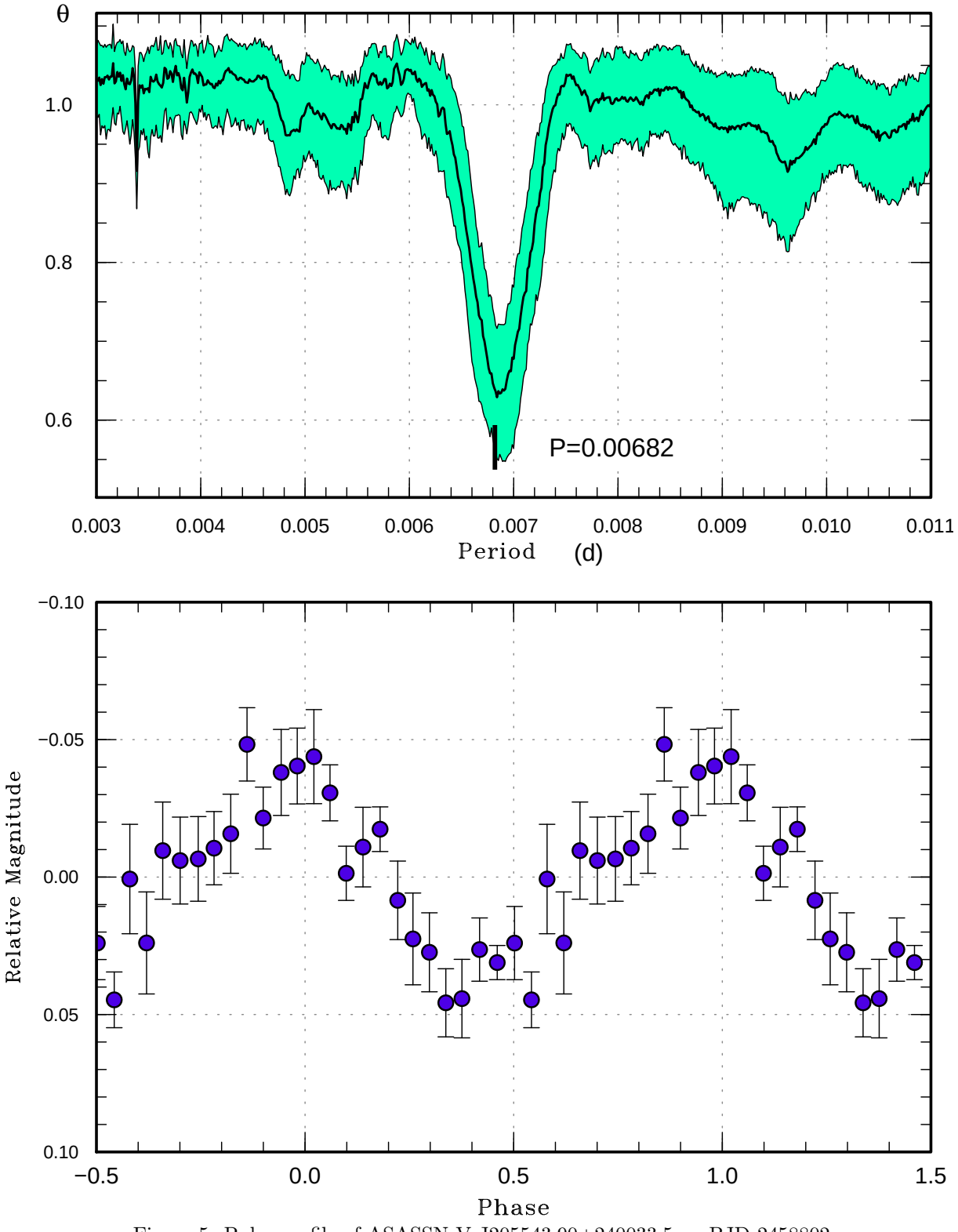

Figure 5: Pulse profile of ASASSN-V J205543.90+240033.5 on BJD 2458802.

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