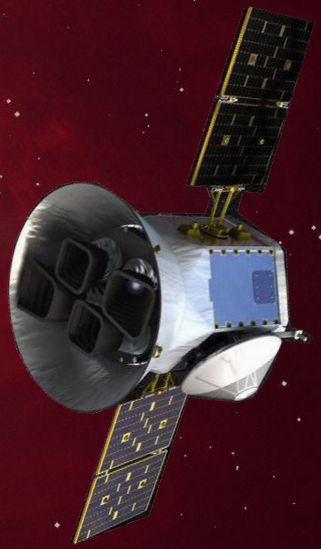
Exploring Small-Scale Brightness Variations in Nova Vulpeculae 2021 with TESS

Kirill Sokolovsky

Yue Shen, Colin J. Burke,
Yu-Ching Chen, Zachary Stone,
Junyao Li, Konstantin Malanchev
University of Illinois Urbana-Champaign
Koji Mukai *(NASA/GSFC)*, Laura Chomiuk, Elias Aydi *(Michigan State)*,
Justin D. Linford *(NRAO)*, Jennifer L. Sokoloski *(Columbia)*,
Robert M. Quimby *(San Diego State)*, Simone Scaringi *(Durham)*,
Claude-André Faucher-Giguère *(Northwestern)*



Images:
NASA/TESS and
artist's impression of RS Oph
DESY/H.E.S.S., Sci. Comm. Lab

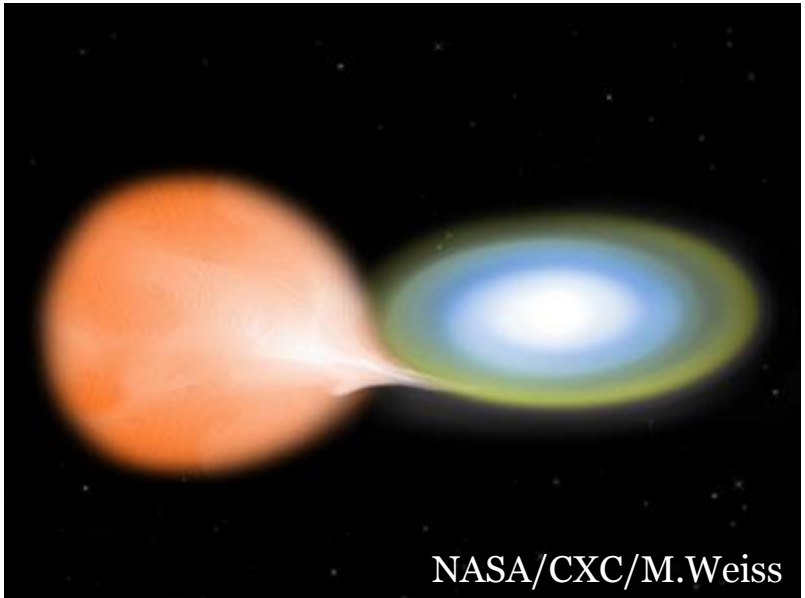
Classical nova

Thermonuclear runaway on accreting white dwarf

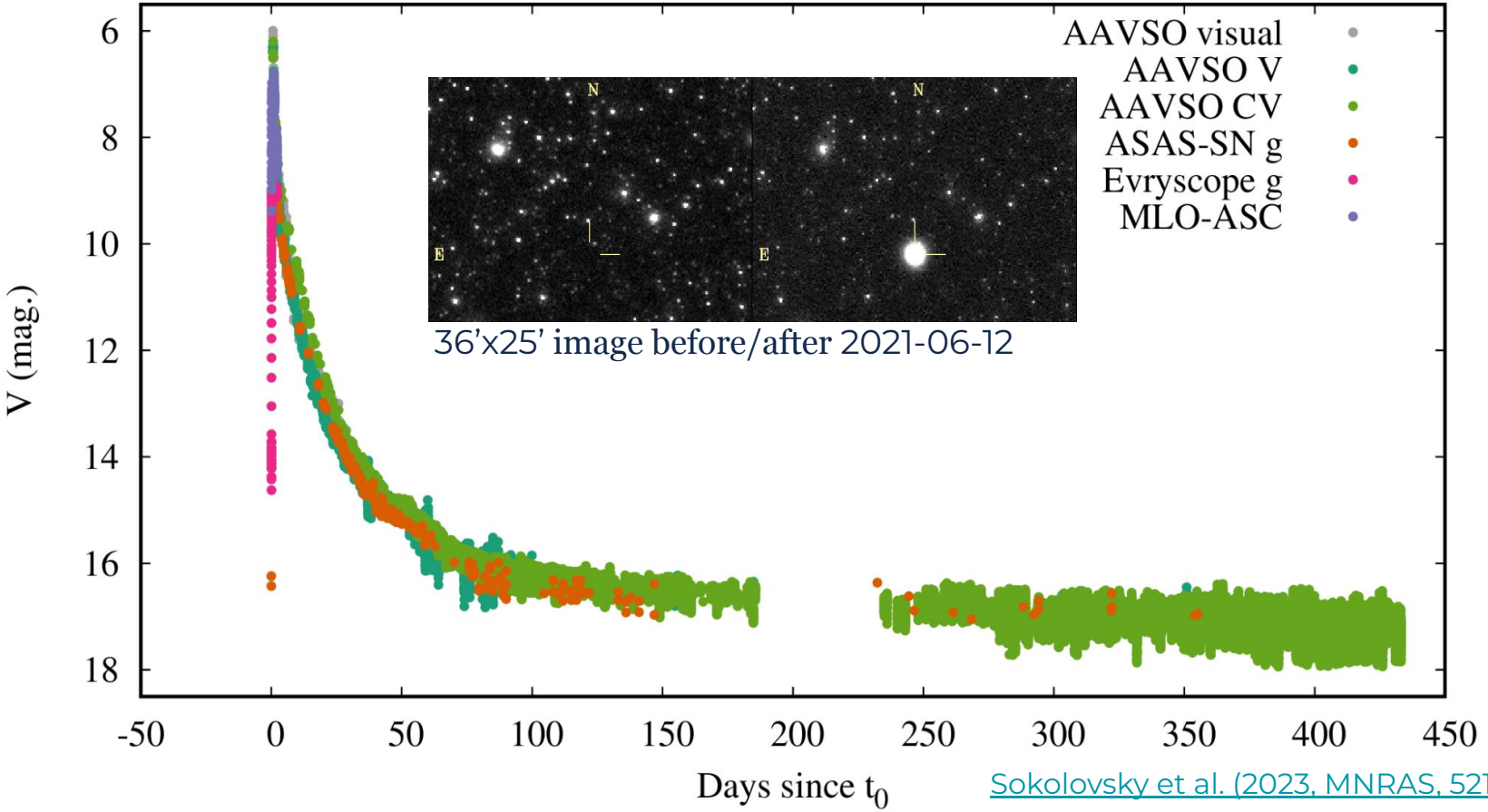
Makes host binary brighter by 8-15^{m}, M_V~ -4^{m} to -10^{m}

for weeks to months

- born-again giant star
- common-envelope binary
- transient TeV to radio emission



A simple nova lightcurve (V1674 Her)

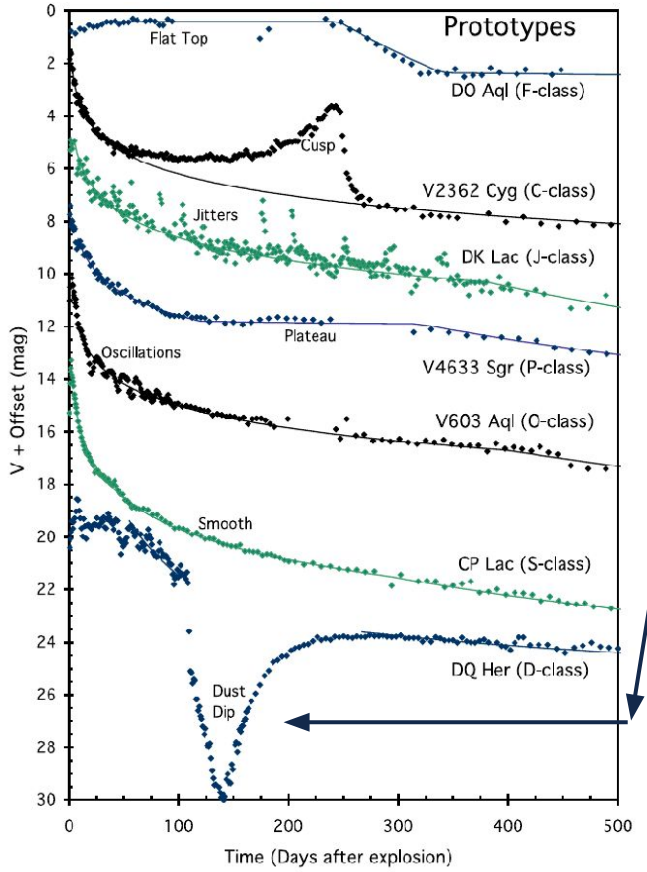


36'x25' image before/after 2021-06-12

Sokolovsky et al. (2023, MNRAS, 521, 5453)

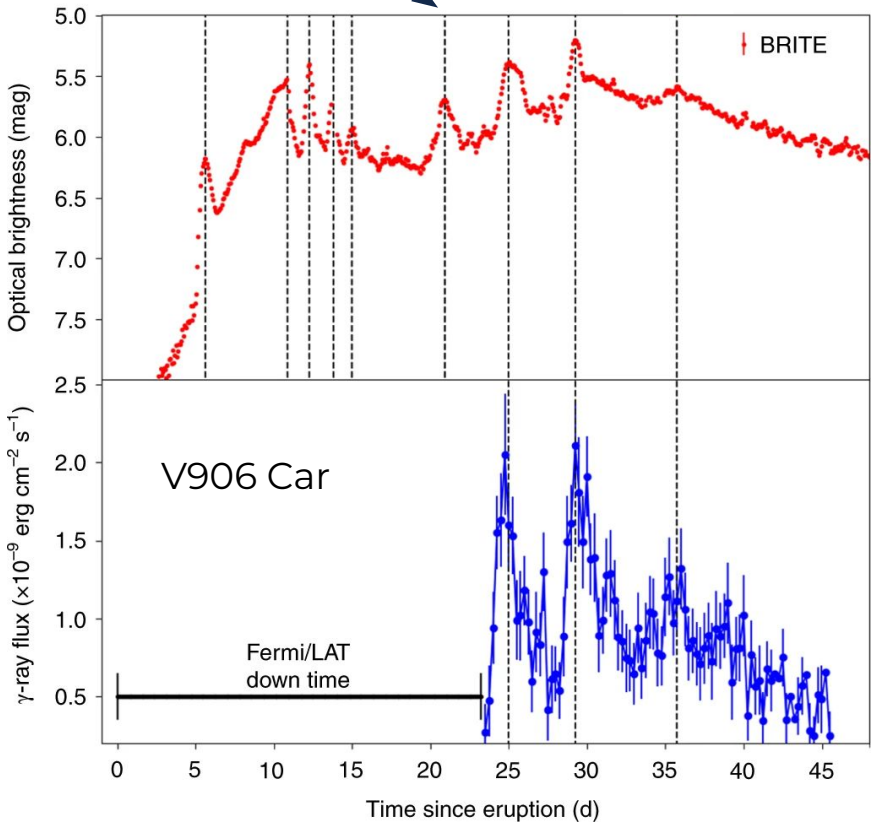
Few nova lightcurves are simple

dust dips + shock-powered flares + unexplained features



Prototypes of light curves classes. The seven binned light curves show the distinct features of each class

Strope, Schaefer, Bradley & Henden (2010, AJ, 140, 34)



Aydi et al. (2020, Nature Astronomy, 4, 776)

TESS: precise photometry over large FoV

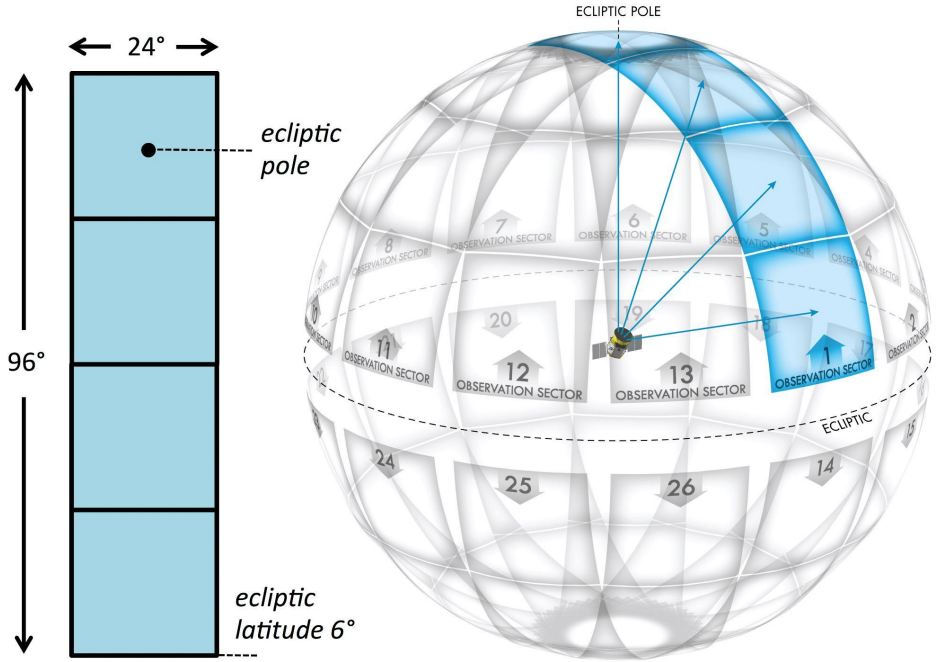
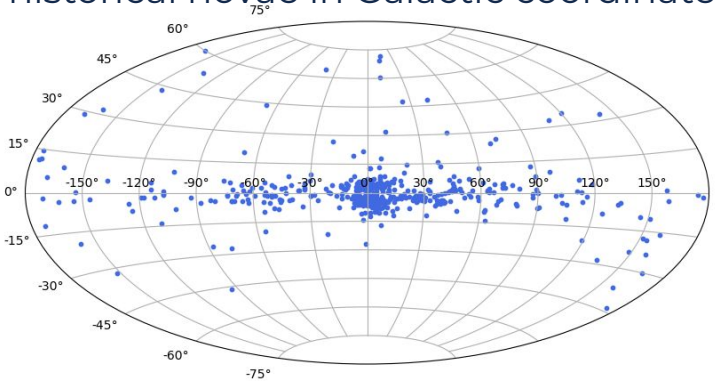


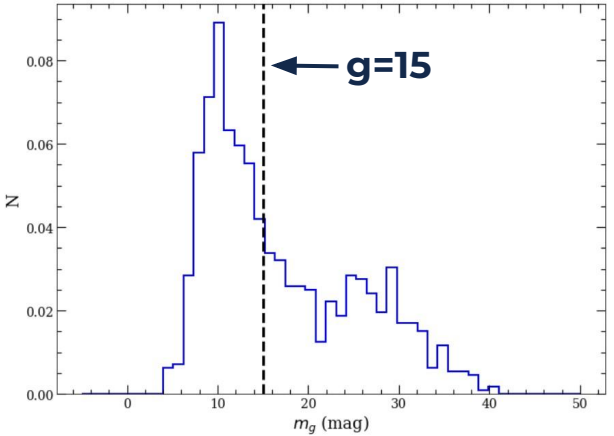
Image: NASA/TESS

Novae: 25/yr (10/yr found)

493 historical novae in Galactic coordinates

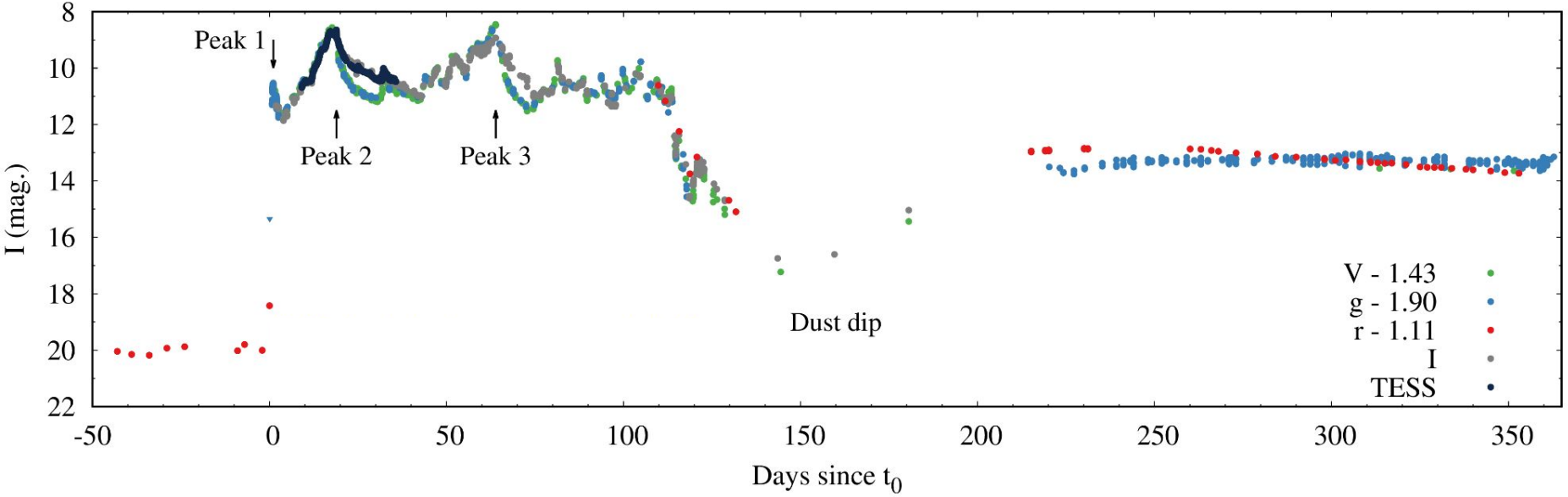


Simulated peak magnitudes of novae



Kawash et al. (2021, ApJ, 922, 25)

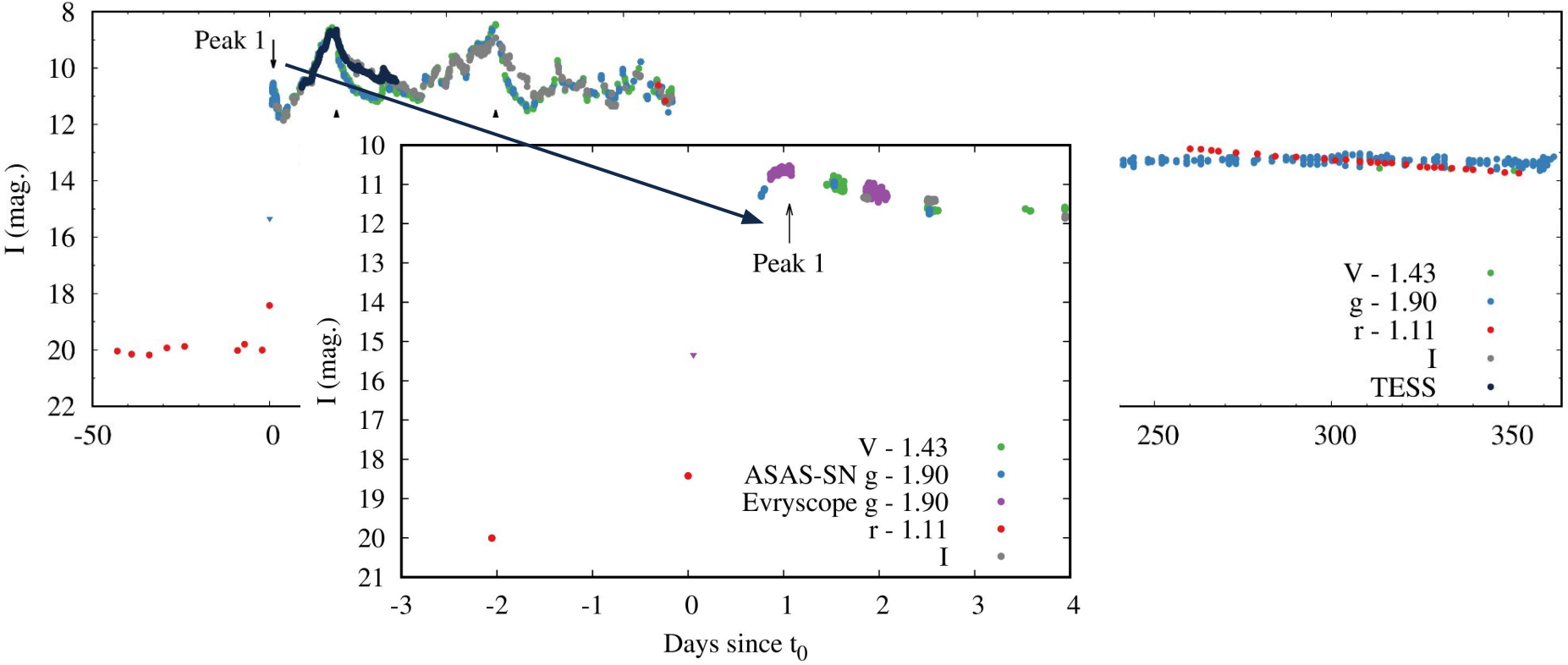
V606 Vul: slow nova with multiple peaks



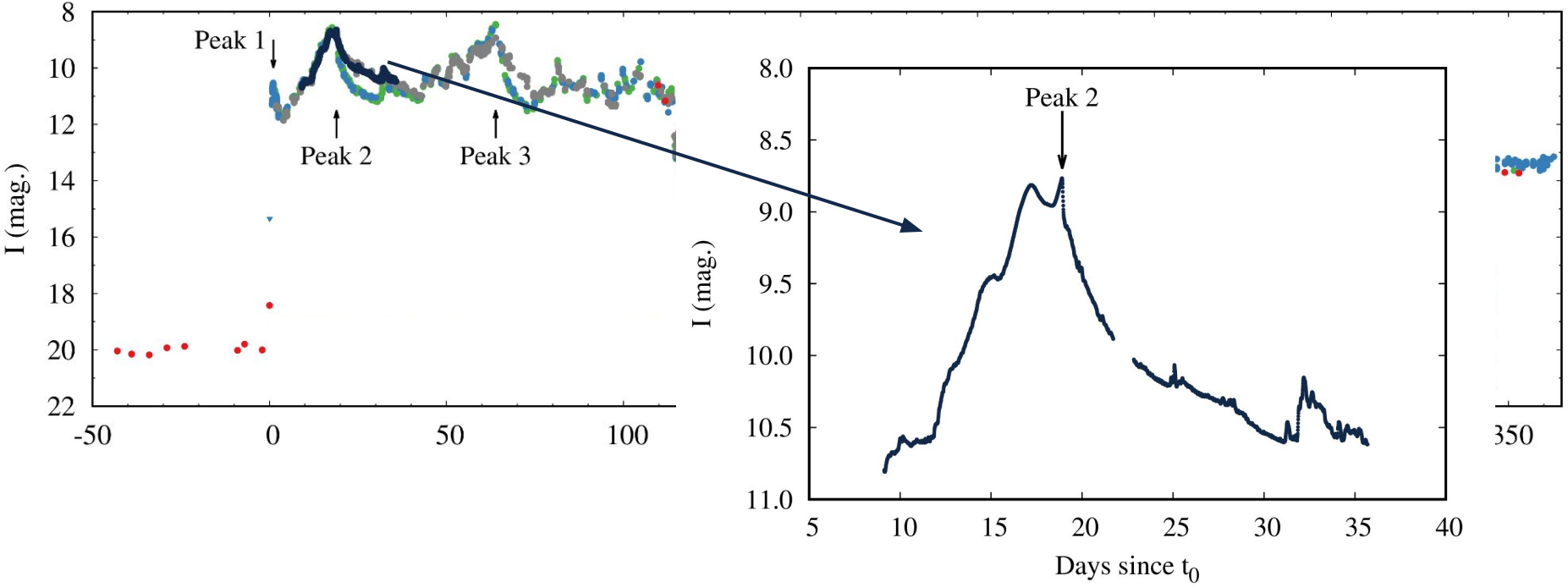
t_0 = 2021-07-15.384

The lightcurve combines ZTF, ASAS-SN, Evryscope, AAVSO and TESS data

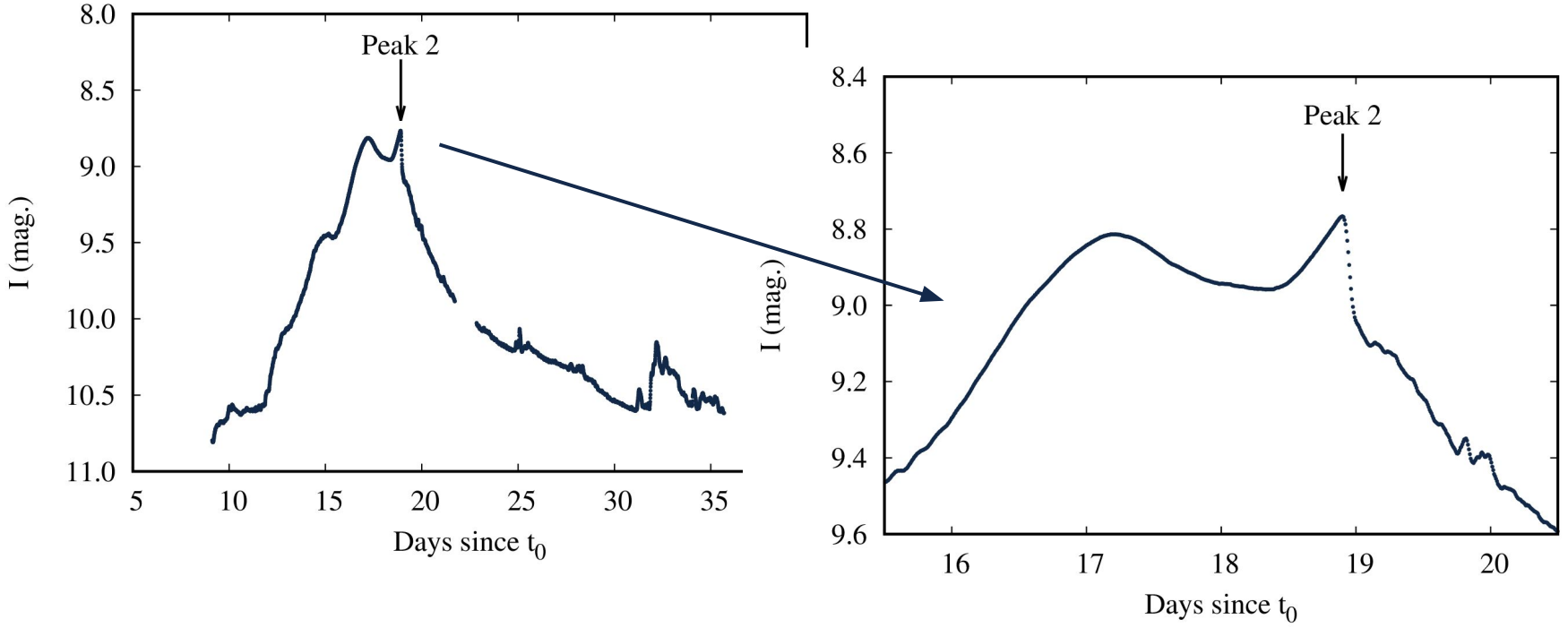
V606 Vul: rise by 9.5mag in 25 hours



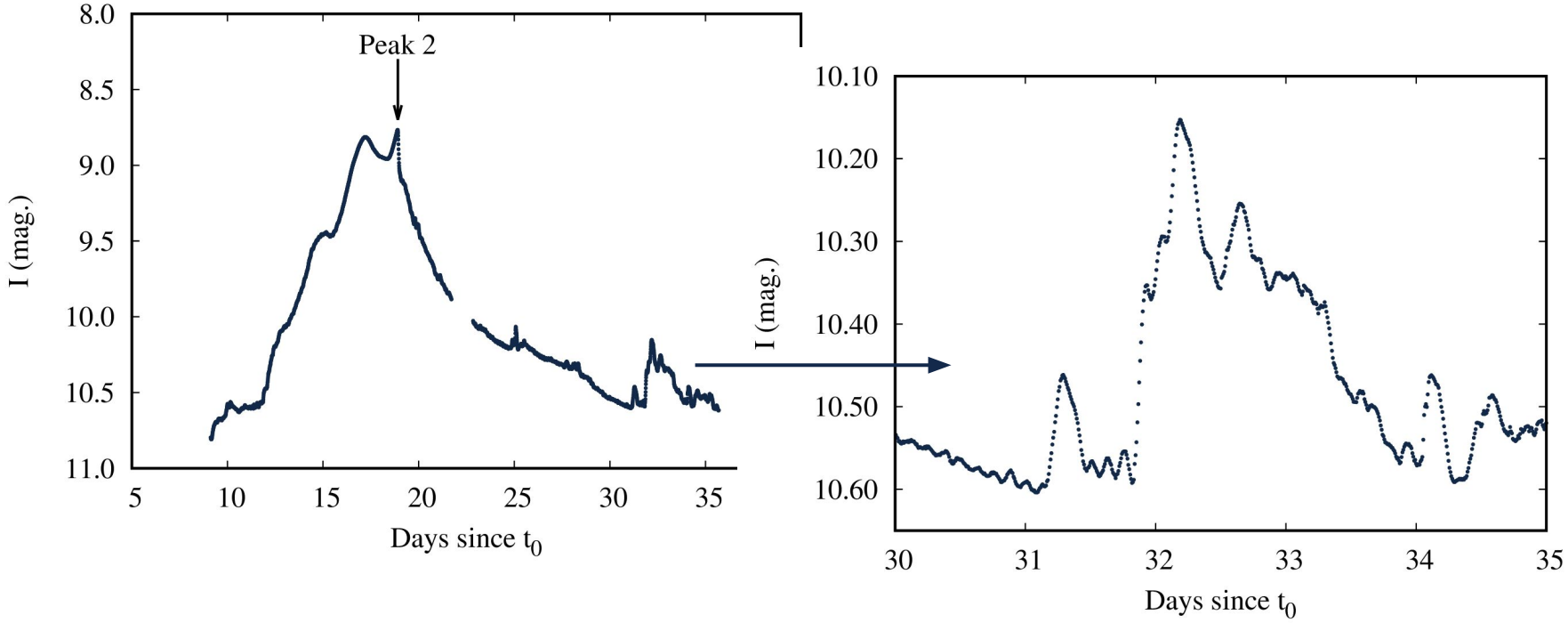
V606 Vul: TESS sector covers Peak 2



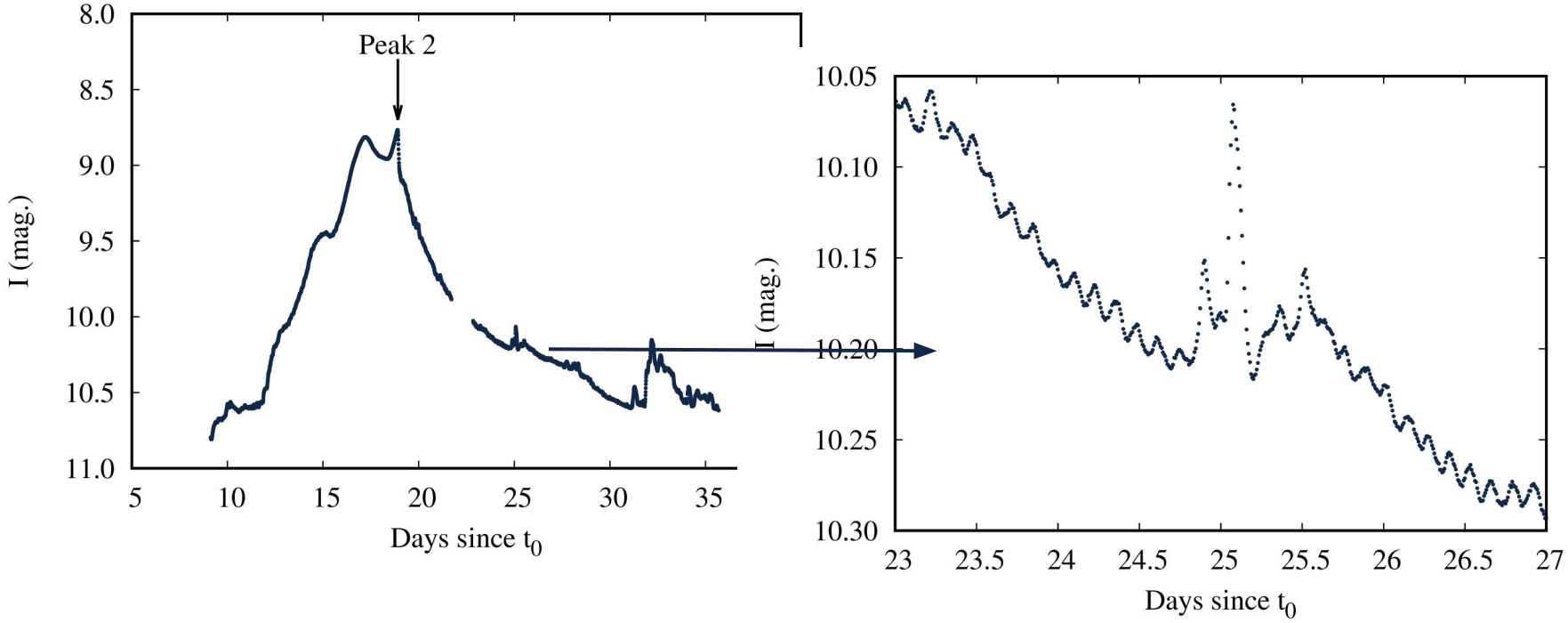
Peak 2: flare atop a broad peak



A series of mini-flares



Mini-flares and oscillations



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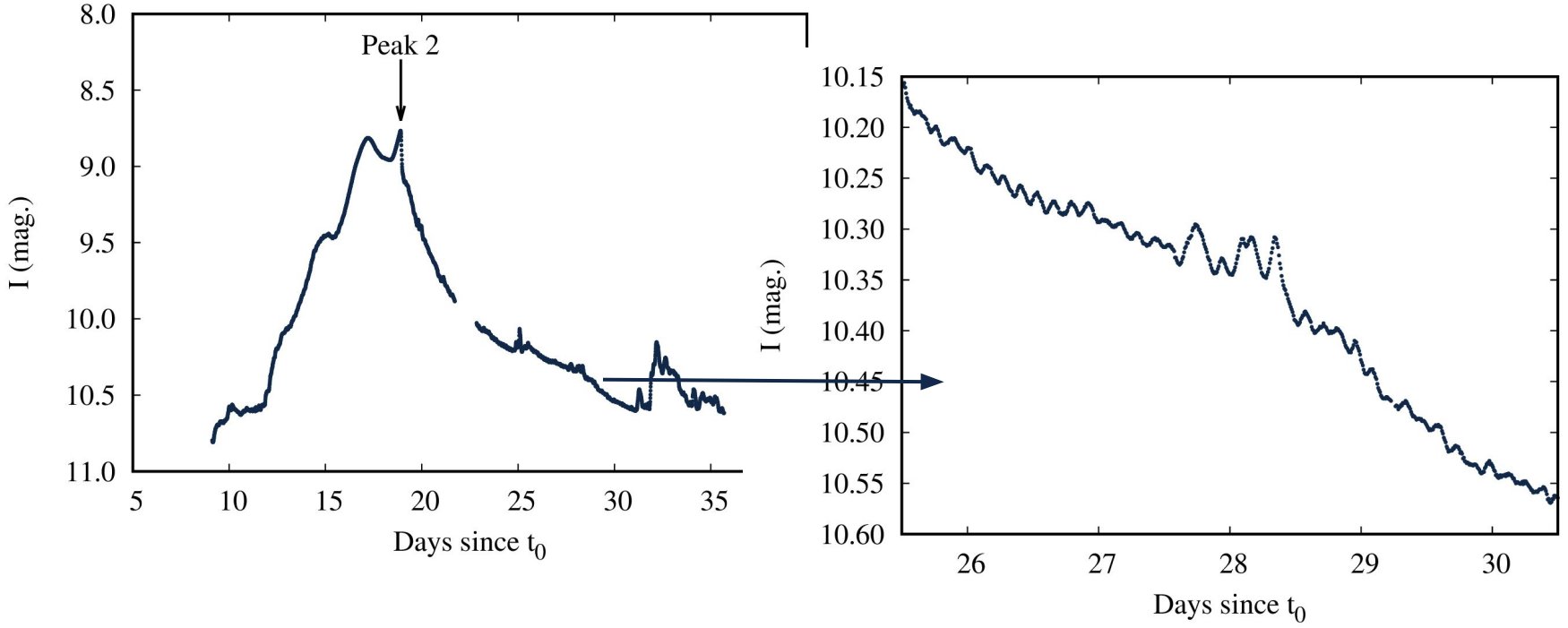

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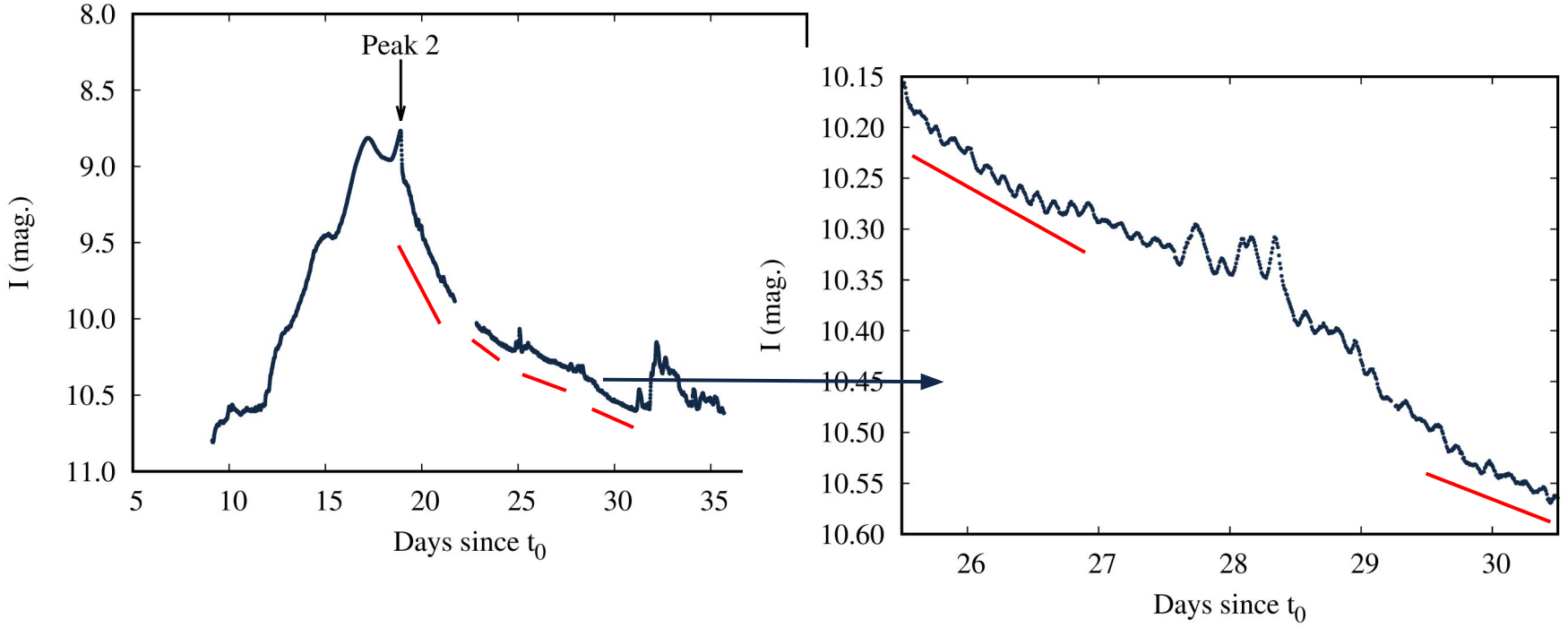
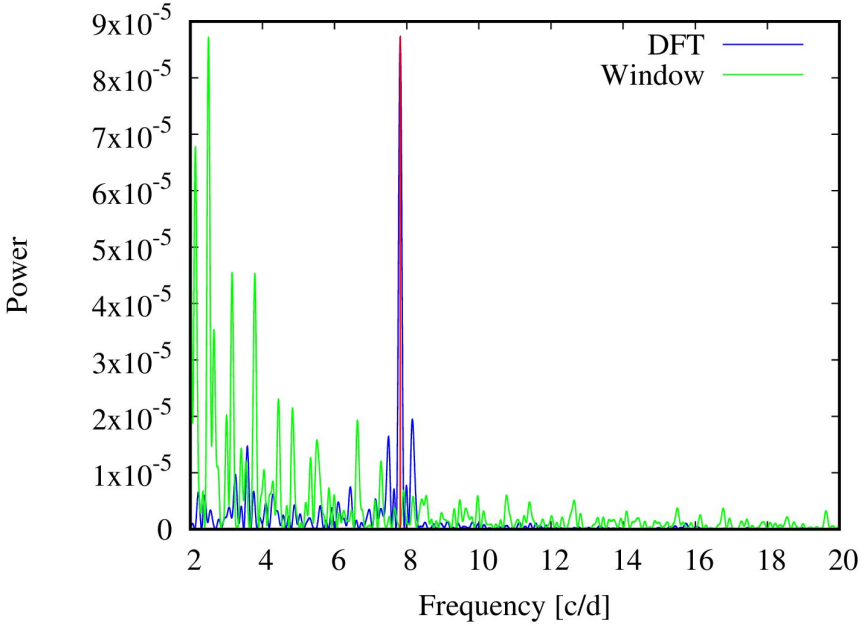
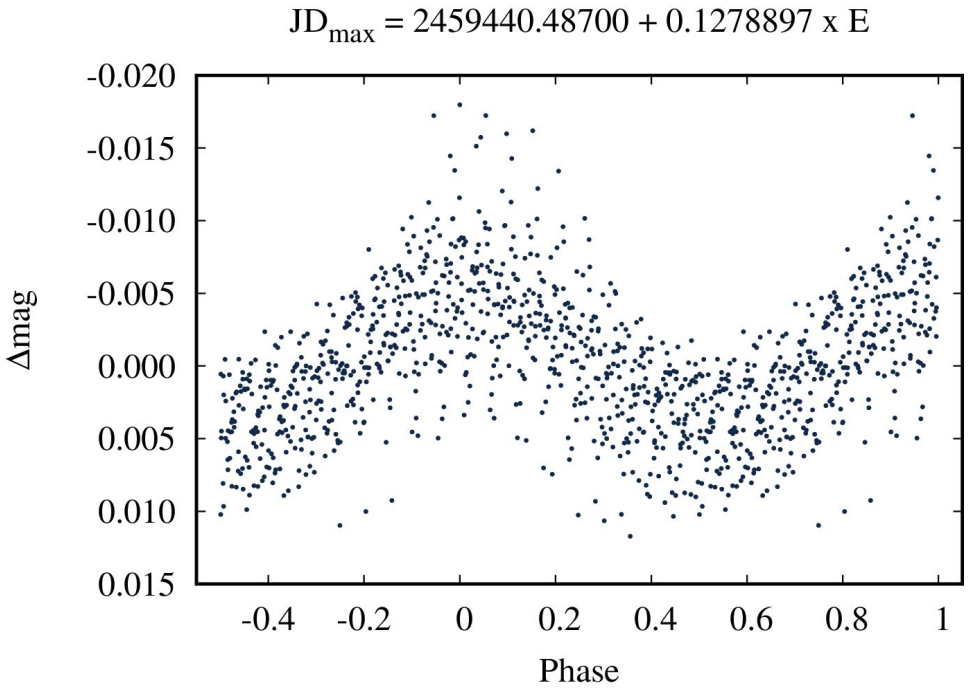
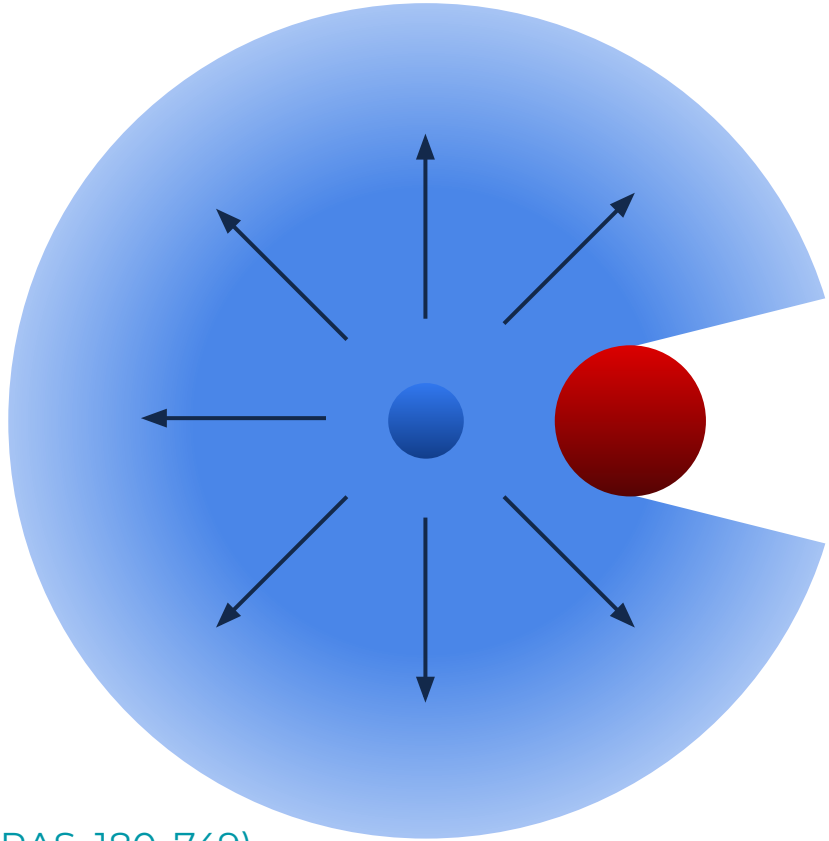


Oscillations are periodic - 3 h 04m





Azimuthal asymmetry in nova photosphere?



Fabian & Pringle (1977, MNRAS, 180, 749)

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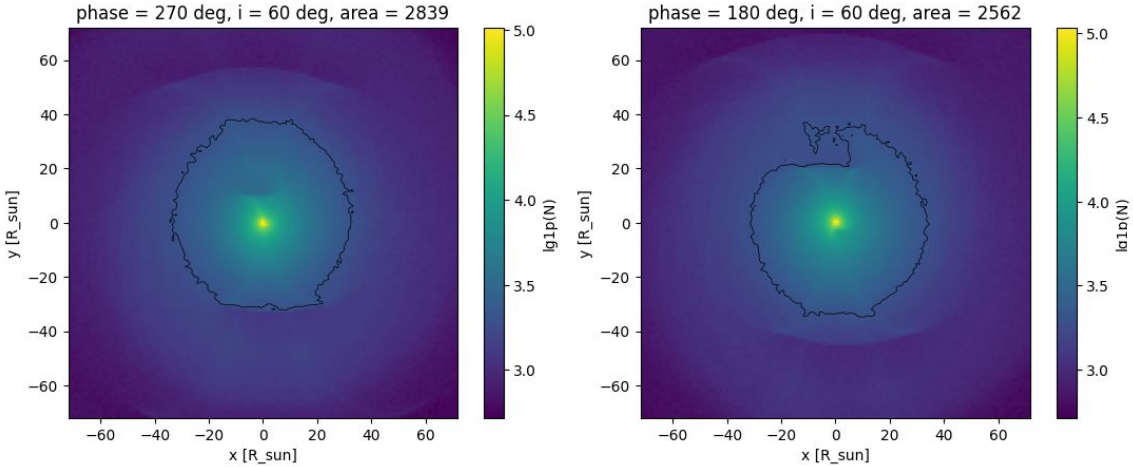
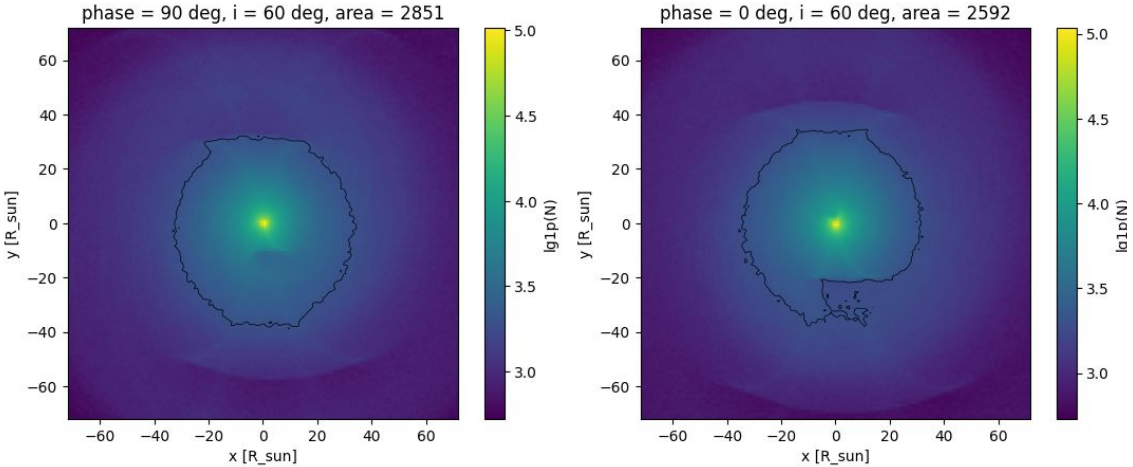
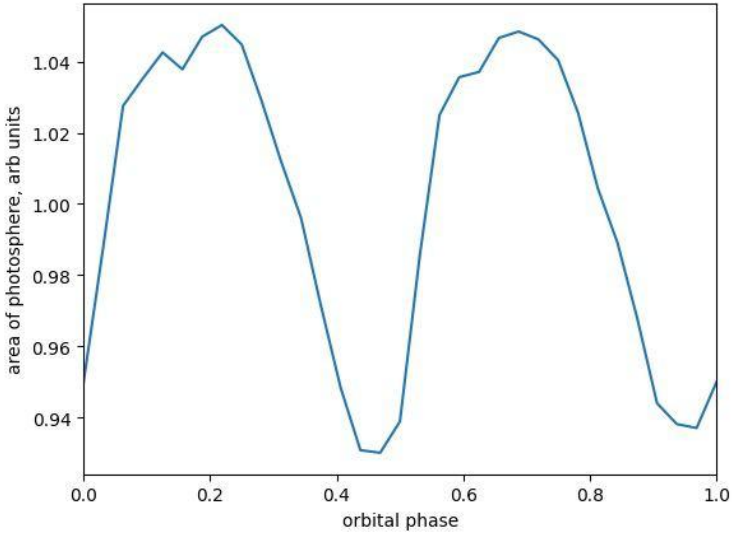


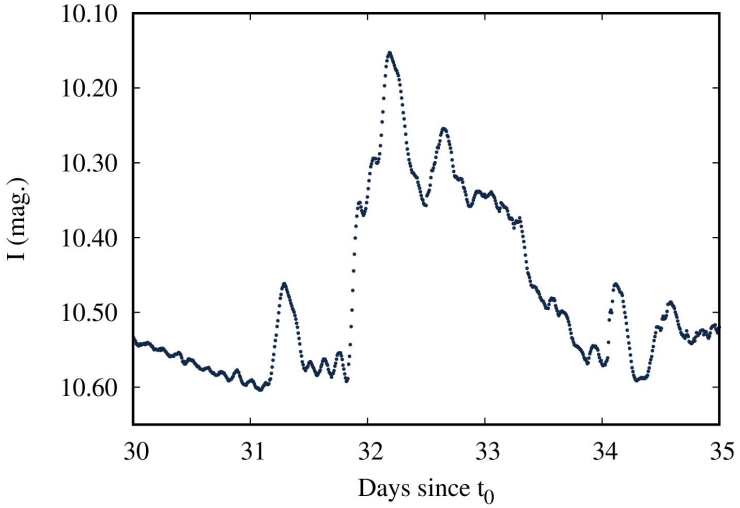


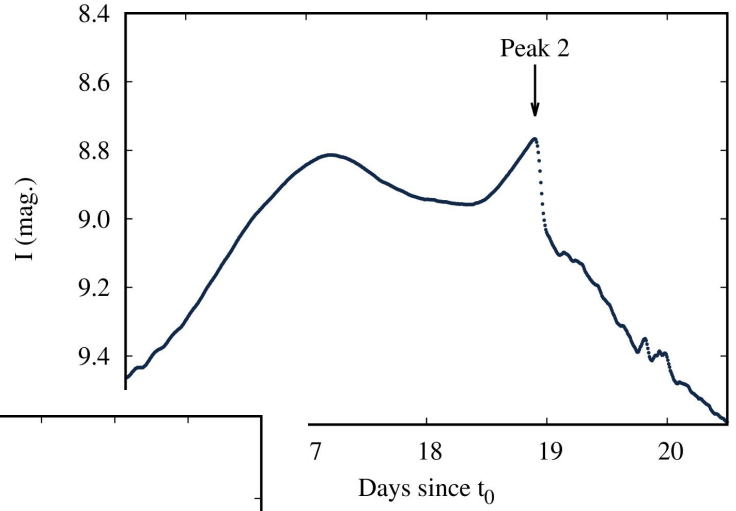
Disturbed nova wind model
by **Konstantin Malanchev**

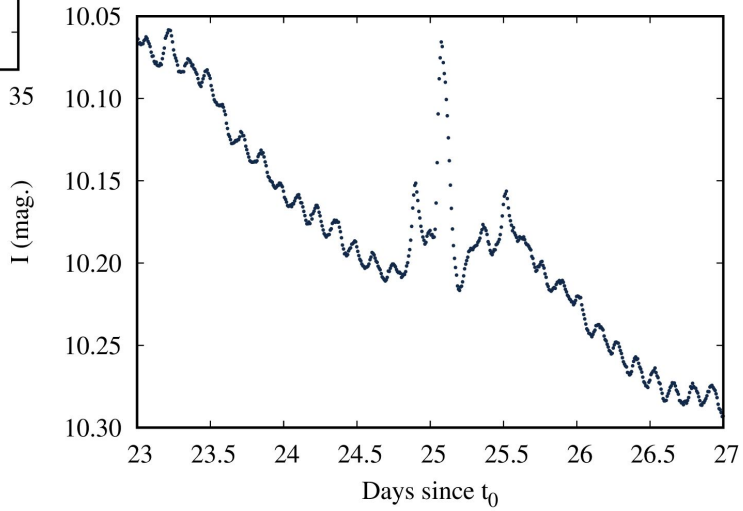


Preliminary!

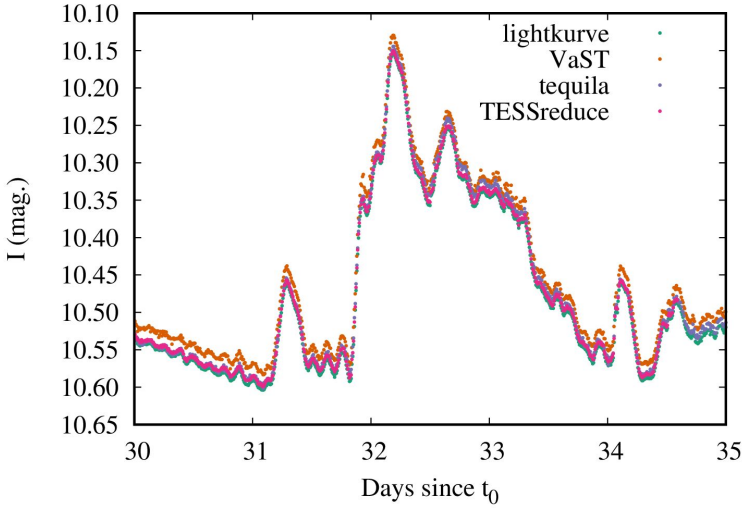
Mini-flares: shocks caused by mass ejections?

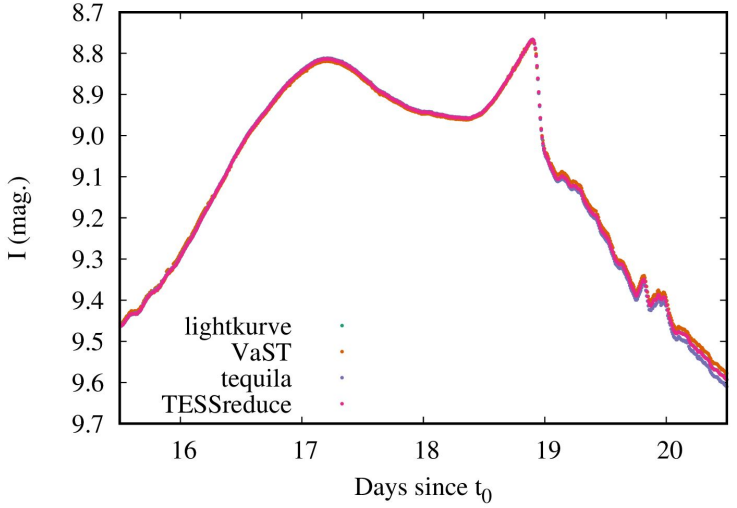


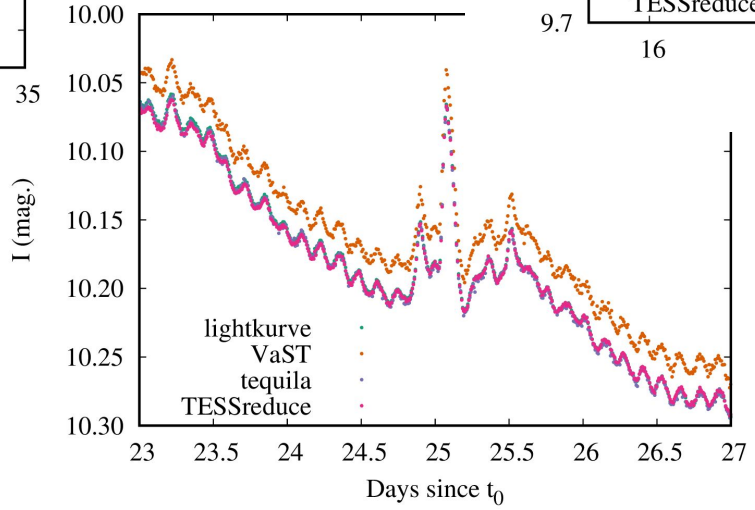




TESS photometry codes comparison







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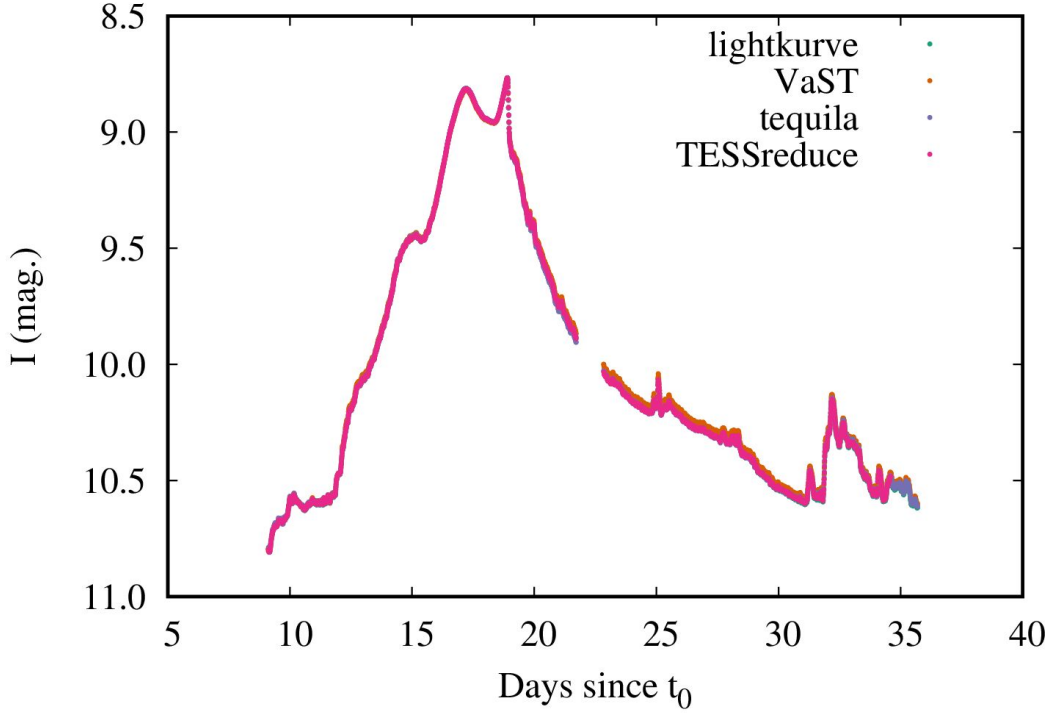


Aperture photometry

Lightkurve

ascl:1812.013

VaST

Sokolovsky & Lebedev (2018, A&C, 22, 28)

Image subtraction

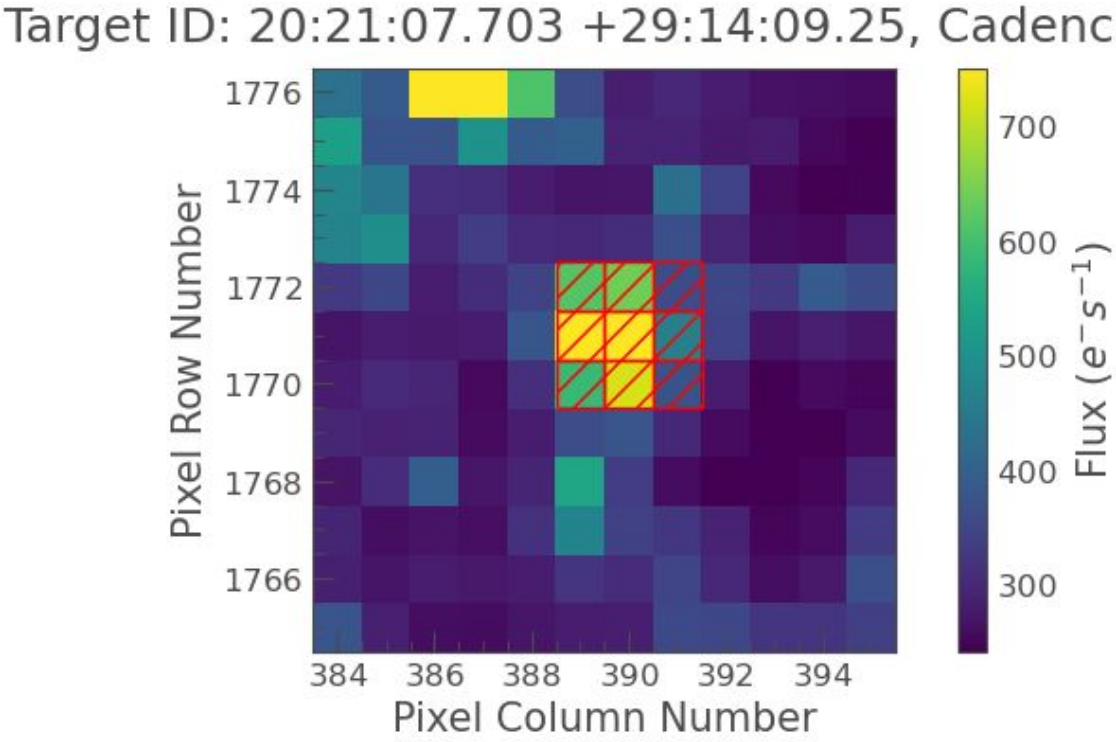
tequila

(under development)

TESSreduce

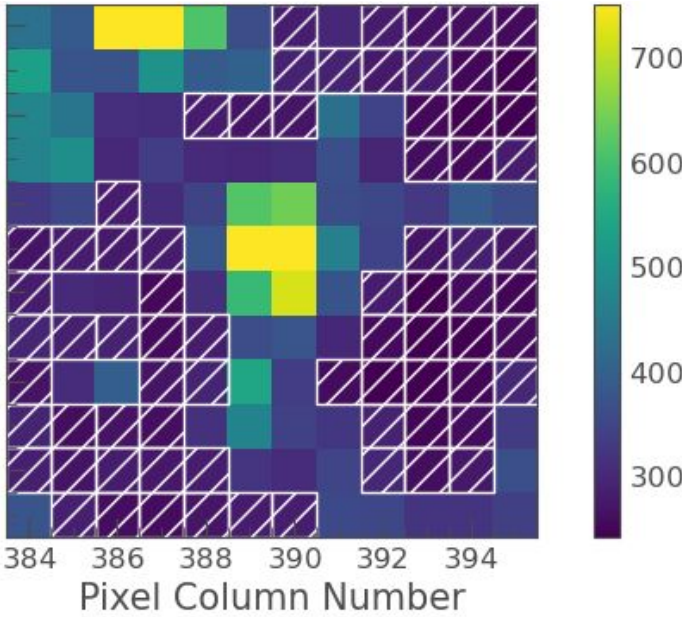
Ridden-Harper et al. arXiv:2111.15006

Visuals from the Lightkurve analysis



Source

Background



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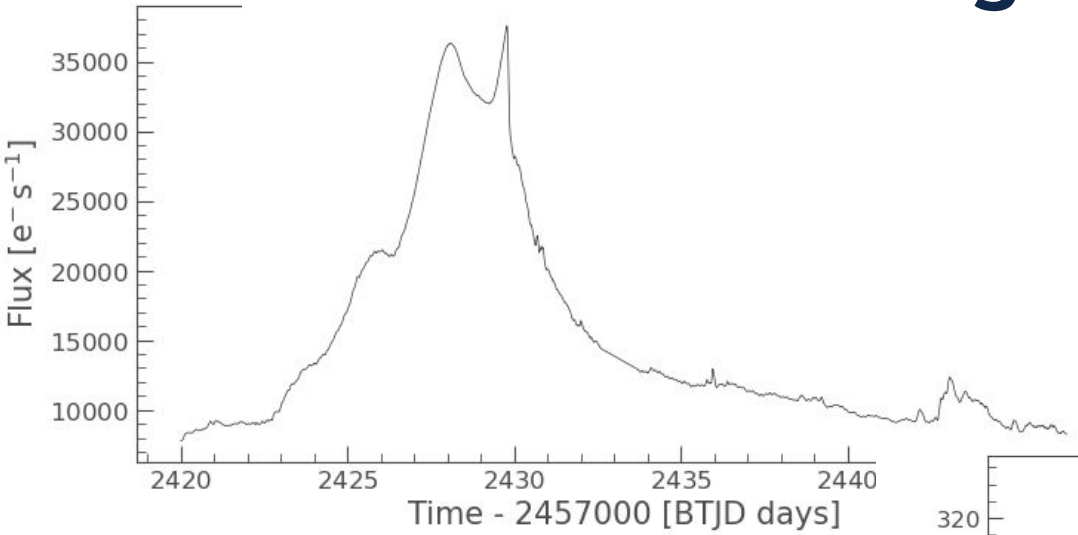
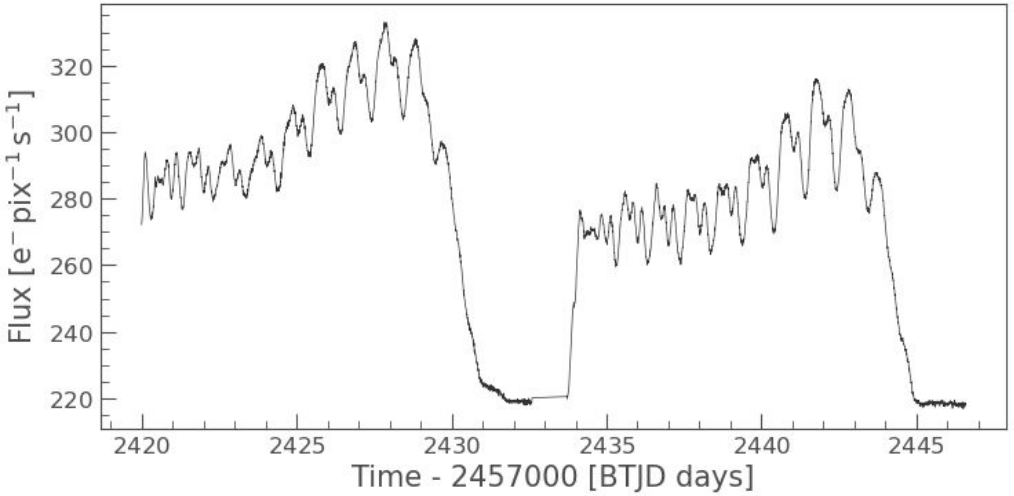


Source (aperture)

Background (per pixel)



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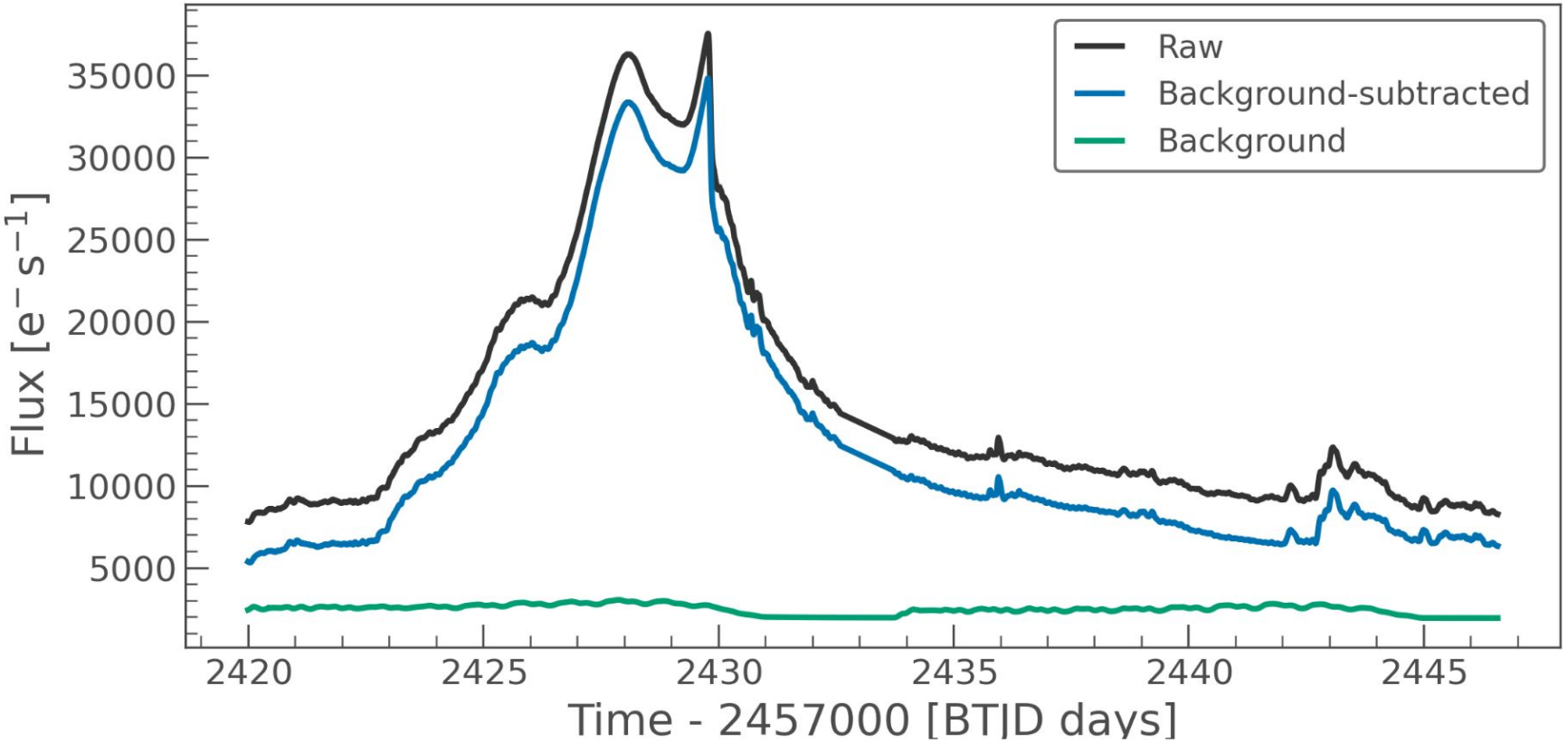

Summary

- TESS is an **exceptionally stable photometer** (compared to anything on the ground). The only catch is the highly variable background.

- Galactic novae are **convenient bright targets** for TESS.

- TESS revealed **periodic modulations** surprisingly close to the nova peak. Possible explanation: asymmetric nova photosphere disturbed by the underlying binary.

- **Mini-flares** of uncertain origin: (mass ejections? shocks? but what triggers them?)