

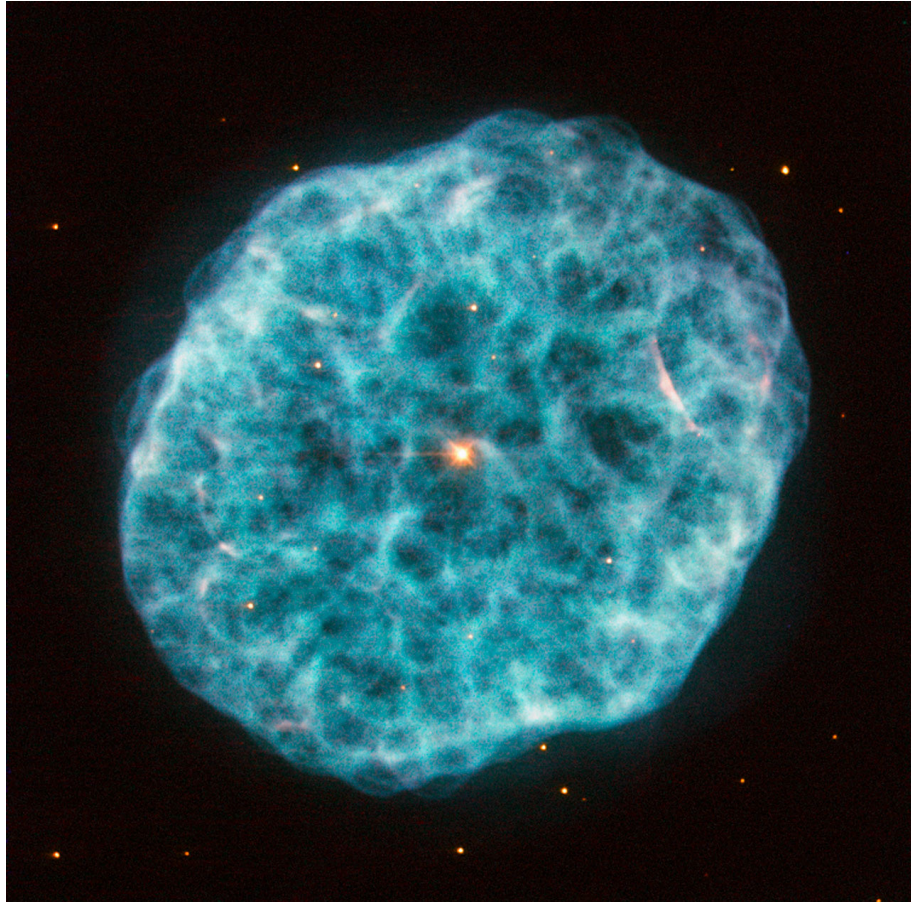
Sub-day Periodic Variability of the Central Stars of Planetary Nebulae Revealed by TESS: NGC1501 and DdDm 1

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Why monitoring the central stars of planetary nebulae (**CSPNe**) ?



NGC 1501

- **Pulsation**
Stellar pulsations cause regular brightness variations on short timescales.
- **Rotation / stellar activity**
Rotation can modulate starspots and magnetic activity, changing brightness with time.
- **Binary companion**
A close companion can cause eclipses or reflection effects, producing variability.

Hour-scale variability provides a window into post-AGB angular momentum and close-binary evolution.

Why is TESS needed?

Ground-based surveys

Daily observing gaps create strong aliases, making periods below ~ 1 day difficult to confirm.

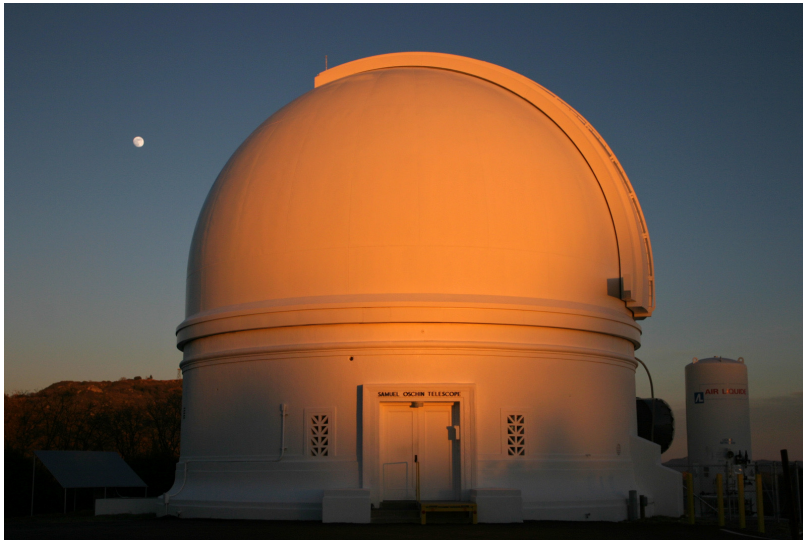


Image credit: Caltech/Palomar

TESS space-borne photometry

Nearly continuous space-based photometry bypasses daily aliasing and reveals hour-scale variability.

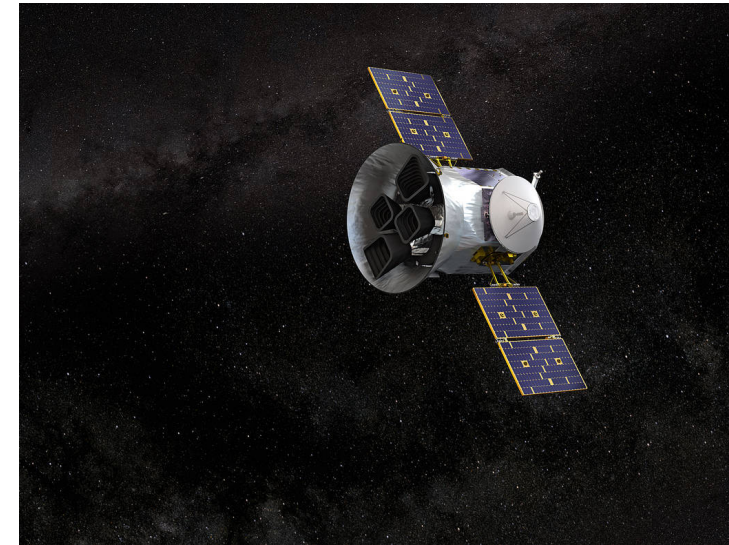
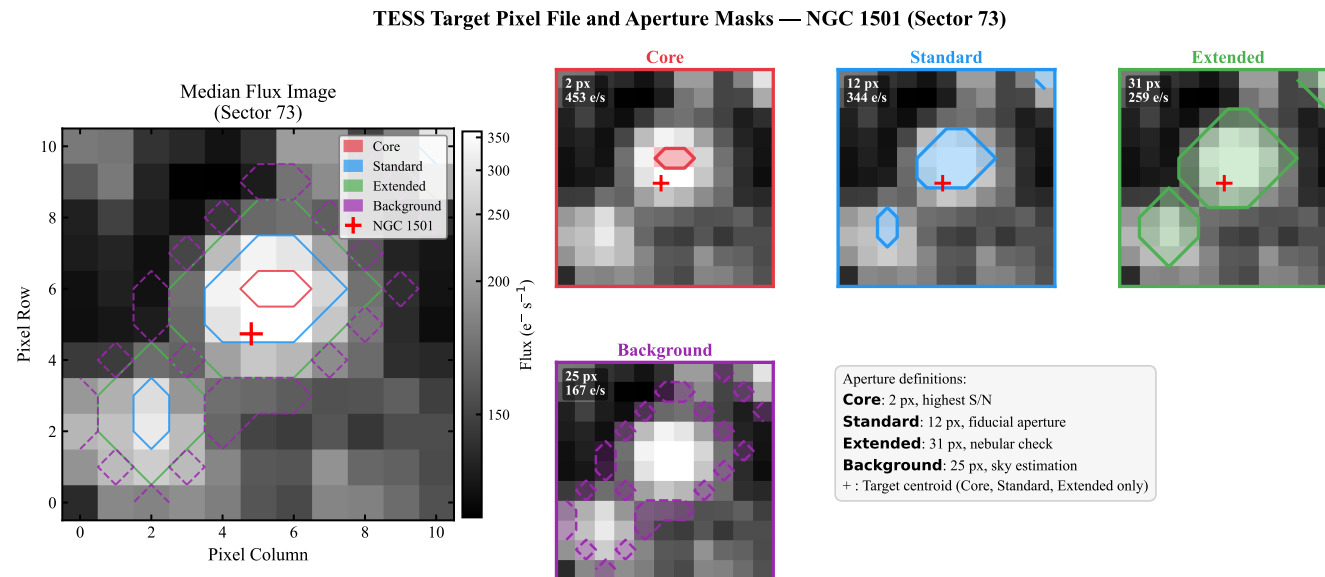


Image Credit: NASA's Goddard Space Flight Center

TESS opens short-period windows for CSPNe.

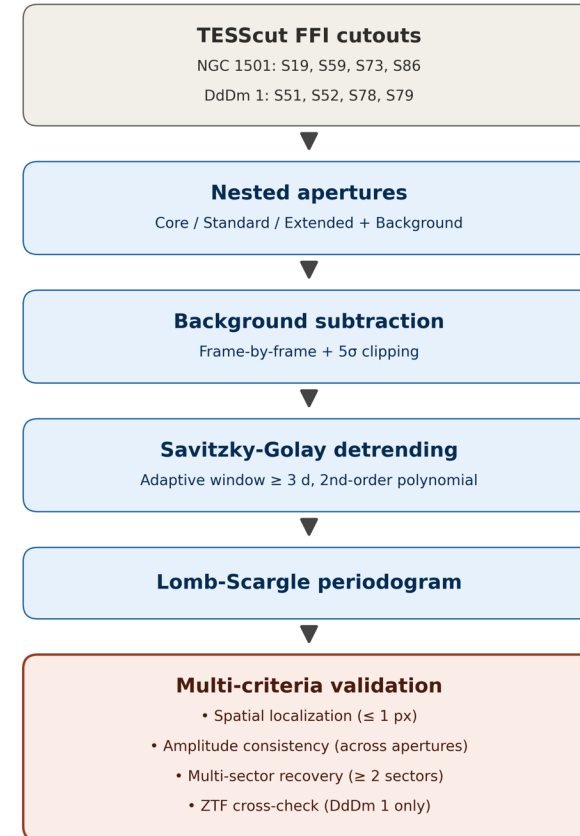
How did we extract reliable signals?

We did not simply download a light curve — we built a custom pipeline to handle nebular contamination and validate real signals.

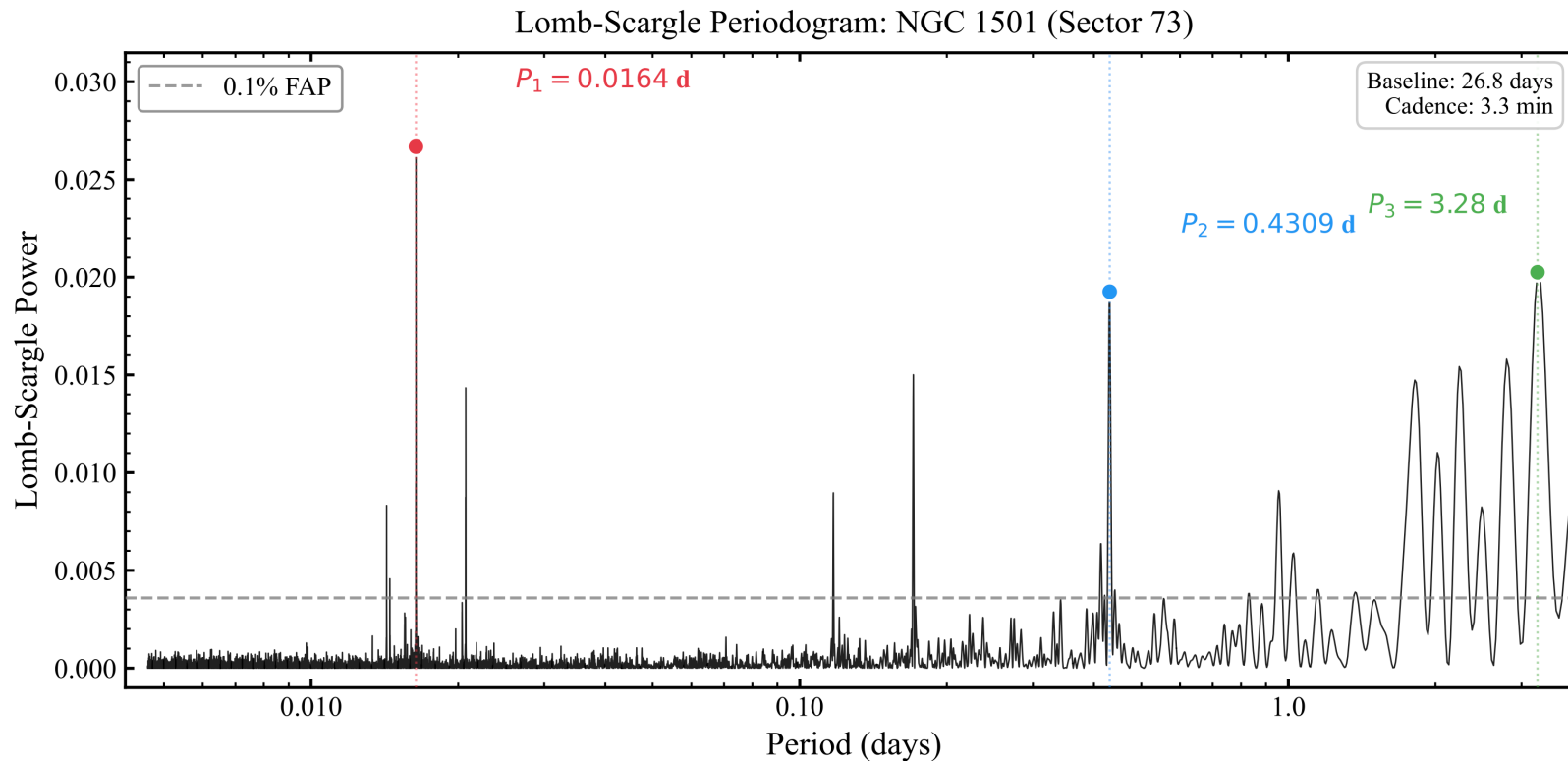


Nested apertures test whether the signal remains stable as nebular contamination changes.

A signal is accepted only if it passes spatial, aperture, and multi-sector validation, with an additional ZTF cross-check for DdDm 1.



NGC 1501 (a disk PN): a new 10.3hr-period signal



Known signals recovered

$P_1 = 0.0164$ d = 23.6 min

$P_3 = 3.28$ d

New signal detected

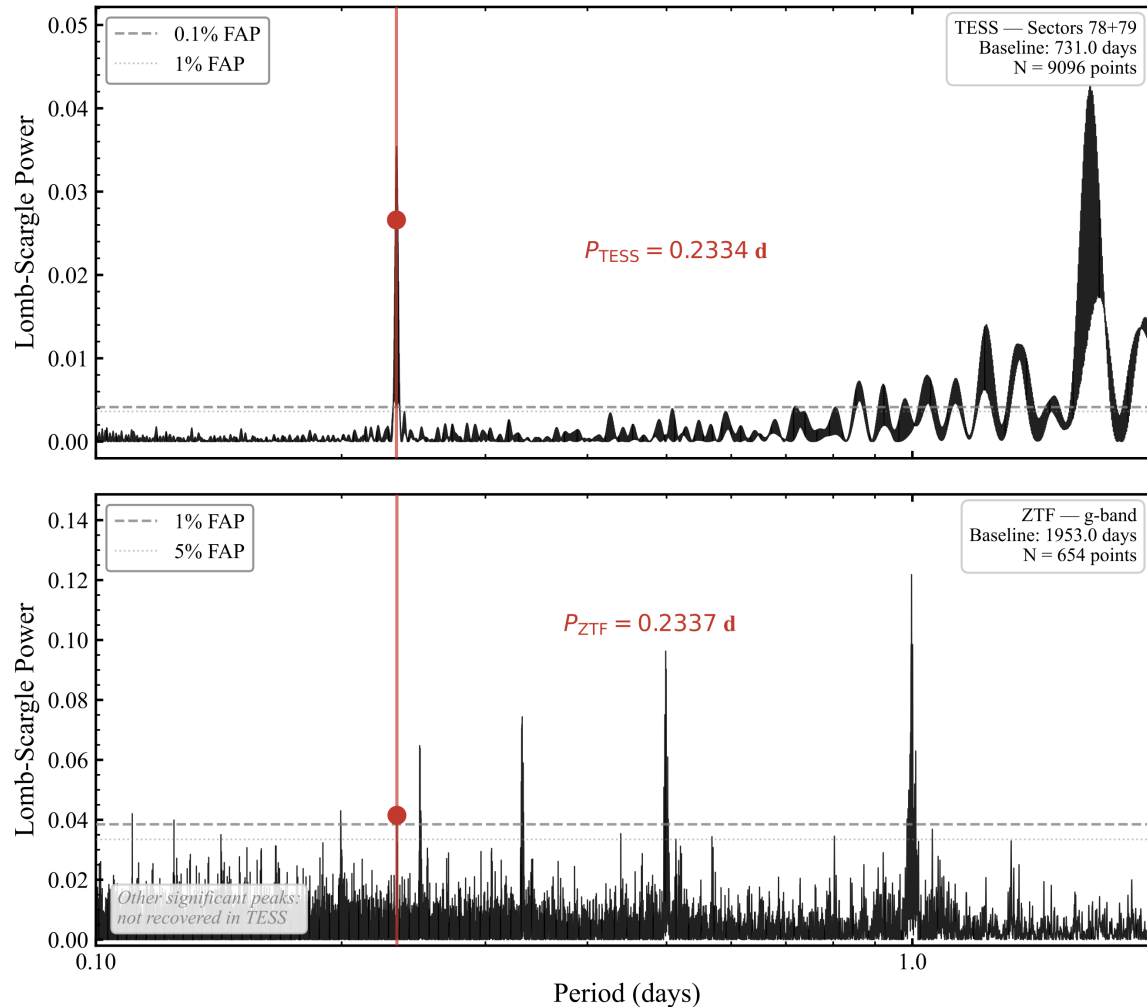
$P_2 = 0.4309 \pm 0.0001$ d = 10.3 h

Still open

Physical origin requires follow-up spectroscopy.

TESS reveals a new intermediate-timescale signal between the known pulsation and long-period modulation.

DdDm 1 (a halo PN): first detected variability, confirmed by ZTF



$P = 0.2336 \pm 0.0002 \text{ d} \sim 5.6 \text{ hours}$

ZTF: $P = 0.2337 \text{ d}$

The same signal appears in two independent datasets.

Independent TESS–ZTF agreement provides a strong cross-check of the detected variability.

Take-away: TESS opens the hour-scale window

10.3 hours

NGC 1501 shows a new intermediate-timescale signal at **$P = 0.4309 \pm 0.0001$ d**, between its known rapid pulsation and long-period modulation.

5.6 hours

DdDm 1 shows its first reported photometric variability at **$P = 0.2336 \pm 0.0002$ d**, independently recovered in ZTF at **$P = 0.2337$ d**.

Next step

Time-resolved spectroscopy will test whether these signals arise from **binary motion, stellar rotation, or pulsation.**

TESS opens a new window on hour-scale variability in planetary nebula central stars, revealing signals that are difficult to confirm from the ground.



Thank You!

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