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Tomo-e Light-Curve Analysis: Variable Stars Identification

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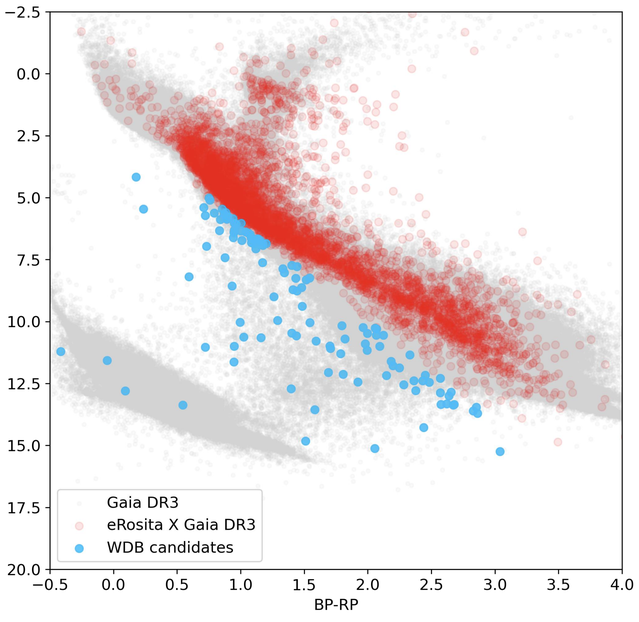
Abstract

We present a light-curve analysis aimed at identifying variable stars using 1-fps movie data obtained by Tomo-e, focusing on sources with luminosity variation timescales shorter than approximately one hour. Our targets are white dwarf binary candidates selected through a crossmatch between Gaia Data Release 3 [1] and the eROSITA soft X-ray catalog [2]. For each frame, the photometric measurements are conducted on each frame using both aperture and point spread function (PSF) photometry, implemented via SExtractor [3] and Photutils [4], where the PSF models are made by stacking the clipped profiles of stars. Zeropoints are calibrated using the Gaia G-band magnitudes of standard stars. Depending on the stellar density in each frame, processing time ranges from approximately 10 to 70 seconds. For a 16th magnitude star, the typical light-curve standard deviation is about 0.05 mag when the zeropoint reaches deeper than 24.3 mag. The magnitude–magnitude standard deviation relation shows that for most stars (including long-period variables with minimal variation during observations), the photometric precision is limited primarily by photon noise. In contrast, significant outliers in this relation are indicative of variable stars, allowing us to effectively identify variability candidates.

Observation

➢ Binary candidates (X-ray sources)



- ➢ Previously show luminosity variation in the Tomo-e database
- ➢ Observation during November-April
- ➢ 1-fps (or 2-fps if brighter than 14 mag)
- ➢ High gain mode
- ➢ About 40-min observation in total of each target

Reference

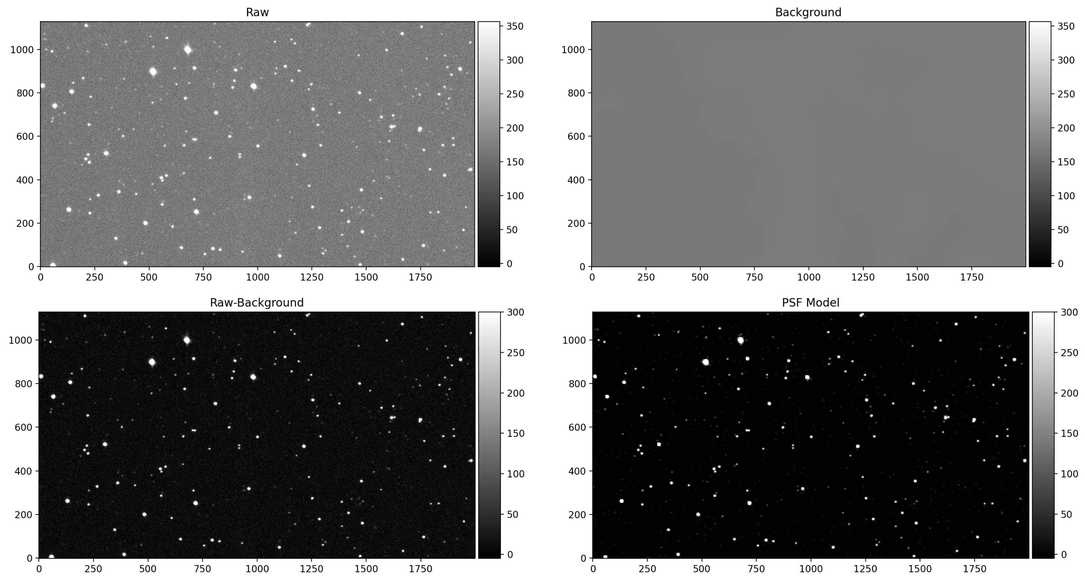
[1]Gaia Collaboration, “Gaia Data Release 3. Summary of the content and survey properties”, Astronomy and Astrophysics, vol. 674, Art. no. A1, EDP, 2023. doi:10.1051/0004-6361/202243940.

[2]Merloni, A., “The SRG/eROSITA all-sky survey. First X-ray catalogues and data release of the western Galactic hemisphere”, Astronomy and Astrophysics, vol. 682, Art. no. A34, EDP, 2024. doi:10.1051/0004-6361/202347165.

[3]Bertin, E. and Arnouts, S., “SExtractor: Software for source extraction.”, Astronomy and Astrophysics Supplement Series, vol. 117, pp. 393–404, 1996. doi:10.1051/aas:1996164.

[4]Bradley, L., “Photutils: Photometry tools”, Astrophysics Source Code Library, Art. no. ascl:1609.011, 2016. ascl:1609.011.

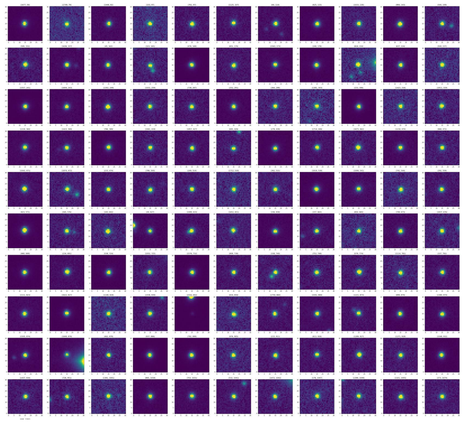
Photometry



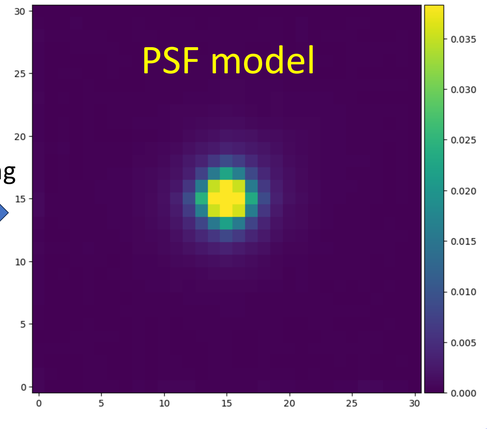
Find Stars
- 13 – 17 mag

Clipped Stars
- 60-frame-stacked

PSF photometry



PSF modeling



Results: Light Curves