An NIR Bright Variable Star Survey toward the Galactic Center with the Thirty Millimeter Telescope

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1. The Missing Piece in Modern Astronomy

While modern gigantic telescopes (such as the Thirty Meter Telescope or Extremely Large Telescope) push the boundaries of the faint universe, they ironically struggle to observe bright, nearby stars due to detector saturation

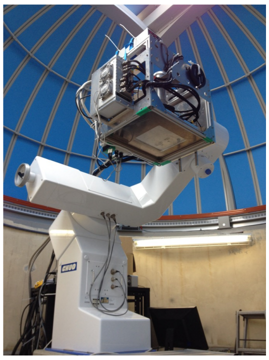
. Currently, high-precision near-infrared (NIR) data for bright stars (e.g., brighter than ~5.5 mag in Ks) is surprisingly scarce

. The 2MASS survey is saturated for these bright sources, and the older Two-Micron Sky Survey (TMSS) only covered the K-band and remains incomplete.

2. Instrument Overview

To break this status quo, we developed the Thirty MilliMeter Telescope (TMMT), a specialized wide-field near-infrared imaging telescope with a 30-mm aperture.

Item	Spec.
Effective Aperture	30mm
Detector	2k x 2k Raytheon VIRGO HgCdTe array
Filters	MKO-NIR J, H, and Ks
Field of View	~25 deg^2 per pointing
Location	Okayama prefecture, Japan



3. Scientific Goals

The TMMT operates semi-automatically and is currently conducting two major long-term surveys.

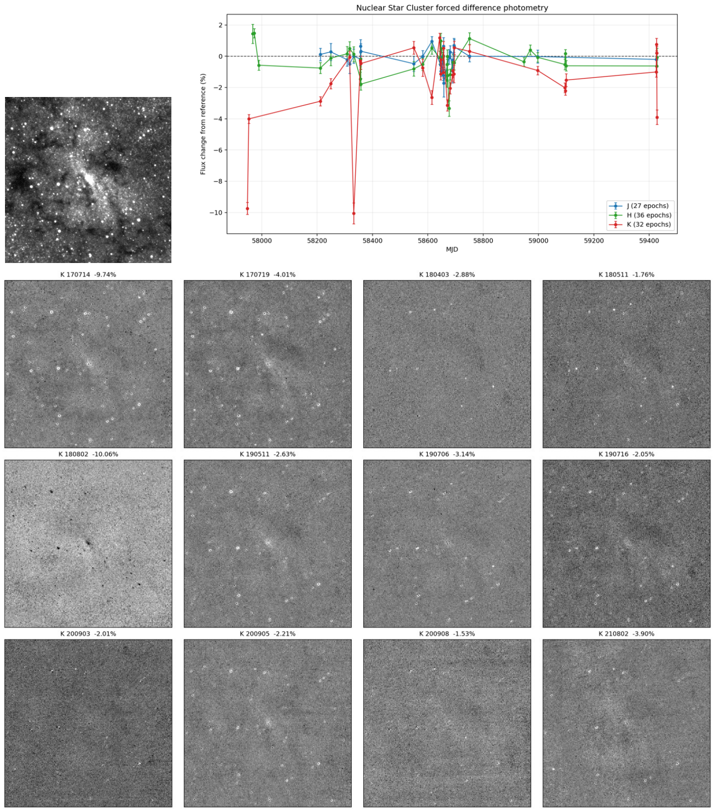
1. Northern Sky Photometric Survey:
Mapping the northern Galactic plane (|b| ≤ 5°, δ ≥ -30°) to provide a high-precision J-, H-, and Ks-band photometric catalog for bright stars, filling the "data desert" left by 2MASS and TMSS.

2. Galactic Plane Variable Star Survey:
A multi-epoch monitoring survey providing systematic time-series data to characterize the infrared variability of bright stars such as Cepheids and Miras.

4. Preliminary Results
Variability of the Nuclear Star Cluster?

Nuclear star clusters in distant galaxies usually cannot be resolved into individual stars and can only be observed through their integrated light. The Galactic Center is, in principle, the only nuclear star cluster for which individual stars can be resolved.

By deliberately observing the Galactic Center at low angular resolution, TMMT provides an unresolved view of the Milky Way nuclear star cluster, analogous to observations of external galaxy nuclei. This allows us to measure how much, on what timescales, and through which physical sources its near-infrared luminosity fluctuates.



CAPTION: TMMT monitoring of the Galactic Center from 2016 to 2022. Band-specific reference images, centered on Sgr A*, were constructed by stacking all available data in each band obtained over the six-year baseline; the K-band reference image is shown in the upper left. The 12 lower panels show randomly selected ZOGY difference images after subtraction of this reference image, illustrating epoch-to-epoch integrated-light variability of the central aperture around Sgr A*. The upper-right panel shows forced photometry at the Sgr A* position on the difference images, using a 3-pixel-radius (~26 arcsec) aperture (~1pc). The plotted values give the fractional flux changes relative to the reference image in the J, H, and Ks bands. The large negative excursions in Ks require further verification and are likely artifacts; nevertheless, coherent variability is seen in H and Ks. The J-band light curve, in which the NSC is not significantly detected in the TMMT data, provides a stringent control against spurious instrumental or subtraction-related variability.

The main goal is not to identify the variability from the light curve alone, but to quantify how much near-infrared variability can be produced by the stellar population of an unresolved nuclear star cluster. This provides an empirical stellar-variability floor for interpreting H/Ks-band nuclear variability in external galaxies, where AGN hot dust, TDE echoes, and variable evolved stars are blended within a single aperture.