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NEOCAM: THE NEAR-EARTH OBJECT CAMERA

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ABSTRACT

The Near Earth Object Camera (NEOCam) is a NASA mission proposal designed to detect, discover and characterize a large fraction of the asteroids and comets that most closely approach the Earth, the Near-Earth Objects (NEOs). NEOCam consists of a 0.5 m infrared space telescope and a passively cooled wide-field camera operating at two thermal infrared channels: 4-5 μm and 6-10 μm. The project was first proposed in 2005 and again in 2010 to NASA's Discovery program. It was selected for technology development funding in 2010. The dataset provided by a next-generation thermal infrared survey for NEOs would offer improved scientific understanding of the origins and evolution of our solar system, advance knowledge of the risk of NEO impacts, and identify and characterize the best targets for future human and robotic exploration (c.f. Abell et al. 2009). Such a survey has been considered for some time (e.g. Cellino et al. 2000, 2003, 2004, Tedesco et al. 2000), but the required long wavelength infrared sensor technology was not considered sufficiently mature.

The NEOWISE survey (Mainzer et al. 2011ab, 2012ab) has served as a pilot project that demonstrated the ability of space-based infrared telescopes to detect, discover, and characterize NEOs. NEOWISE has delivered detections of ~700 NEOs to date,

with more expected to be mined from the data in the near future. While delivering valuable information on the numbers, orbital elements, and physical properties of the NEOs and their subpopulations, NEOWISE was not originally designed and optimized for NEO discovery; it relied upon solid hydrogen to maintain the operating temperature of its 12 and 22 μm detector arrays, which was depleted after 8 months. Furthermore, its pointing was constrained to a narrow range of solar elongations (~88 – 94 degrees), and its field of view (FOV) was 0.61 square degrees (Wright et al. 2010).

NEOCam leverages the NEOWISE data processing pipeline architecture, but the FOV is significantly larger (~12 square degrees). Furthermore, NEOCam will employ new long wavelength HgCdTe detector arrays that can operate at 35-40 K, temperatures achievable with passive cooling only (similar to the Spitzer Space Telescope Warm Mission) at the Sun-Earth L1 Lagrange point. This orbit offers a benevolent, cold thermal environment while simultaneously enabling high-bandwidth communications with Earth and wide instantaneous viewing zones. The ability to downlink and process full-frame image data is critical for extracting sources at the faintest limits and preserving the opportunity to precover newly discovered objects in older data.

NASA has funded technology development for NEOCam, including the development of long wavelength infrared detector arrays that will have excellent zodiacal background emission-limited performance. Other long-wave arrays used for astronomy (e.g. Si:As) require focal plane temperatures ≤8K (e.g. Spitzer IRAC/IRS/MIPS, WISE, Akari). However, our goal for the NEOCam mission has been to develop long-wave 10+ μm cutoff arrays which function at 30-40K focal plane temperatures, with a preference for ~40K, for ease of thermal design. Teledyne Imaging Sensors has developed and delivered for test at the University of Rochester the first set of approximately 10 μm cutoff, 1024 x 1024 pixel HgCdTe detector arrays in accord with NEOCam requirements. The first measurements of these arrays show the development to be extremely promising: noise, dark current, quantum efficiency and well depth goals have been met by this technology at focal plane temperatures of 35-40K, readily attainable with passive cooling (McMurtry et al. 2012).

Additionally, we have carried out detailed simulations to predict the performance of an advanced space-based telescopic survey. Two potential architectures for the advanced survey were considered: one located at the Earth-Sun L1 Lagrange point, and one in a Venus-trailing orbit. A sample cadence allowing for the self-follow-up necessary for objects discovered in the daytime sky on Earth was formulated and tested. Our results indicate that the Earth-Sun L1 and Venus-trailing surveys achieve similar levels of integral completeness for NEOs after six years.

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