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Preliminary Results from the NEOWISE Mission

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Abstract

NASA's Wide-field Infrared Survey Explorer (WISE) spacecraft was restarted in December 2013. Now renamed NEOWISE, the mission has resumed surveying the infrared sky. The spacecraft's 32 months of hibernation had no significant impact on its performance. The primary science goals of NEOWISE are to detect and characterize near-Earth Objects (NEOs) and other small bodies. Over its three-year mission, NEOWISE will determine radiometrically-derived diameters and albedos of $\sim$ 2000 NEOs and tens of thousands of Main Belt asteroids. NEOWISE is currently detecting $\sim 0.5 - 1.0$ NEOs per day, and as of April 2014, 11 NEOs have been discovered by NEOWISE, most of them larger and darker than those typically discovered by ground-based optical facilities. The NEOWISE team is engaged in diverse small body research that makes use of the NEOWISE data, including thermophysical modeling of NEOs, thermally characterizing comets, and determining rotation properties of Jovian Trojans and Hildas.

1. Introduction

Understanding the numbers, orbits, and physical properties of near-Earth objects (NEOs; asteroids or comets with perihelia less than 1.3 AU) is essential both for characterizing the population of objects that pose a potential impact hazard, as well as for planning an appropriate mitigation strategy should one be discovered on a threatening trajectory. Of the $\sim$ 11000 known NEOs currently discovered, only the most basic properties (orbital parameters and absolute magnitude H) are known for all but $\sim$2000. Roughly 1000 new NEOs are discovered over all size ranges per year; however, well-determined physical measurements such as taxonomic classification or radar-derived sizes and shapes are determined for only $\sim$100 of these. Furthermore, these $\sim 11,000$ known NEOs are only a small fraction of the total population.

Given the need for improvement in our knowledge of NEOs, the NEOWISE mission's primary objectives are to detect, track, and characterize NEOs as well as other minor planets. NEOWISE has begun regular delivery of asteroid and comet candidates to the Minor Planet Center. As with data from the prime mission, the infrared images from the reactivated NEOWISE mission will be useful for characterizing physical properties such as size and albedo for minor planets.

2. Observations

The project began life as the Wide-field Infrared Survey Explorer (WISE; principal investigator E. Wright of UCLA), a NASA Medium-class Explorer mission that surveyed the entire sky in four infrared wavelengths (3.4, 4.6, 12 and 22 μm) [1]. The spacecraft is in a sun-synchronous polar orbit, allowing continuous observations near 90° solar elongation. WISE's primary scientific objectives were to find cool stars and ultraluminous infrared galaxies. However, NASA's Planetary Science Division provided the resources needed to archive and publicly serve all of the single exposures, to create tools to support solar objects out of the data in near-real time. These tools are collectively known as NEOWISE [2]. During the fully cryogenic portion of the prime mission, the NEOWISE project extracted detections of $> 158,000$ minor planets, including $> 34,000$ new discoveries. Among the detections were $\sim$ 700 NEOs (of which 135 were new discoveries) and 160 comets, including 21 new cometary bodies. During the 3-band and post-cryogenic mission phases, $> 13,500$ minor planets were observed, including 116 NEOs [3, 4].

WISE was reactivated in December 2013 and renamed NEOWISE, acquiring $\sim$ 12 images (at a spacing of $\sim$ 3 hours) of each moving object identified. Since the original solid hydrogen refrigerant has been exhausted, an operating temperature of $\sim$ 75K (ensuring background-limited performance in the two bluest bandpasses - 3.4 and 4.6 μm) is achieved passively by pointing at zenith. The 32 months spent in hiberna-

tion have had a negligible effect on the image quality, sensitivity, photometric and astrometric accuracy, completeness, and rate of minor planet detections.

All data products from the NEOWISE prime mission, including the single-frame images and extracted source lists, have been delivered on scheduled. These images and detections are available through NASA's Infrared Science Archive (IRSA) hosted at the Infrared Processing and Analysis Center at Caltech. The restart of NEOWISE will result in the delivery of an additional three years of survey data. Data releases of images and sources will be made annually through IRSA. Candidate minor planet position-time associations ("tracklets") are being delivered to the Minor Planet Center on an ongoing basis. After three years, precession of the orbital plane will make it difficult to keep scattered light out of the telescope's boresight, bringing a natural end to the mission.

3. Science Highlights

The reactivated mission has discovered 11 NEOs as of April 2014, most of which are large and dark. At its completion, the NEOWISE project will provide diameters and albedos for $\sim$20% of the known NEO population. Since reactivating in December 2013, NEOWISE has observed 11 comets, including the previously unknown Halley family comet C/2014 C3 (NEOWISE). NEOWISE has also observed comet C/2013 A1 (Siding Spring; Fig. 1), which will have a close encounter with Mars in October 2014. Various morphologies are apparent throughout the dataset, including dust comae, tails, and trails. In addition, we are able to study the thermal and physical properties of cometary nuclei. CO and CO_2 production rates can be constrained since the 4.6 μm band contains emission lines from these species, enabling us to examine trends of cometary activity with varying heliocentric distance and dynamical family [5].

NEOWISE data have enabled us to advance our understanding of asteroid families by using albedos in conjunction with orbital elements to refine known families and identify new ones that previously could not be disentangled from the background population. These new lists allow us to better constrain the size distribution of family members at the sizes probed by NEOWISE. NEOWISE data have also allowed for measurements of average surface thermal inertia of near-Earth asteroids. We are also using thermal lightcurves to determine rotation properties of Jovian Trojans and Hildas, which help diagnose planetary migration history.

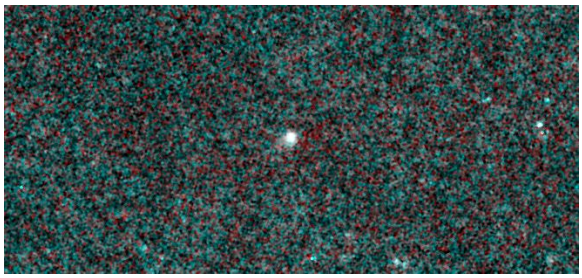

Figure 1: Stacked NEOWISE image comet C/2013 A1 (Siding Spring).

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