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Methods for Simulating Comet Populations in Preparation for the Near-Earth Object Surveillance Mission

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Abstract

The Near-Earth Object Surveillance Mission (NEOSM) will provide unprecedented detection, tracking and characterization of Near-Earth Objects (NEOs) using high-cadence imaging from a space-based infrared telescope. Planning for the NEOSM requires an accurate model of the solar system's small body populations in order to develop efficient operational survey strategies and to assess survey performance once in-flight operations have commenced. The NEOSM Investigation Team is currently developing the Reference Small Body Population Model (RSBPM; [1]) that will contain the current best estimates of the dynamical and physical properties of the solar system's small body populations. Development of the RSBPM will be completed before the NEOSM launch, and the finished product will be peer-reviewed to ensure accuracy. Once the survey begins, we will compare predictions based on the RSBPM to actual observational measurements to calculate the efficiency of the survey, and thus de-bias the survey to properly characterize each population in order to assess Earth impact risks. We present here an update to the methods of incorporating comets into the RSBPM, with particular focus on accurately incorporating dust and CO+CO_2 gas comae activity behaviors. A better understanding of these physical characteristics are relevant for planetary defense (e.g., determining nuclei diameters).

The high abundance of volatile ices (e.g., H_2O, CO, CO_2) present in comet nuclei drives outgassing and dust lofting when the surface material is exposed to the Sun, generating comae and tails. While high-cadence and long-baseline observational campaigns producing physical characterization of nuclei and comae exist for a few comets (e.g. 1P/Halley, 9P/Tempel, 67P/Churyumov-Gerasimenko, C/1995 O1 (Hale-Bopp), C/2012 S1 (ISON)) and have allowed determination of single-apparition secular light curves, predictions for the behaviors of an individual comet are notoriously difficult due to the possibility of outbursts, fragmentation events, complete nucleus disintegration and seasonal effects. This high degree of uncertainty for cometary behaviors introduces complications for

modeling the brightening trends for individual comets as compared to those for the asteroid populations. Fortunately, characterizing the behaviors of comets in the infrared as an ensemble population is a somewhat more tractable problem. Previous (e.g., COBE [2], AKARI [3], Spitzer [4]) and ongoing surveys (e.g, Pan-STARRS [5], Zwicky Transient Facility [6], ATLAS [7], WISE/NEOWISE [8]) detecting large numbers of comets in the infrared are allowing a framework through which an individual comet's activity behaviors can be estimated based on behavior trends in infrared emission of the larger ensemble. We are utilizing derived ensemble properties from these observational campaigns to develop a recipe for best simulating the morphological and photometric behaviors for the solar system's comet populations.

NEOSM will utilize a space-based 50-cm aperture infrared-optimized telescope located at the Sun-Earth L1 Lagrange position. It will contain a single instrument with a dual-channel infrared imaging camera that will survey the sky in bandpasses at 4-5.2 microns (denoted NC1) and 6-10 microns (denoted NC2). NC1 images of comets will mostly contain thermal emission (for comets within ~3 au of the Sun) from the nucleus and any dust coma/tail/trail. Additionally, the bandpass of NC1 covers the CO_2 gas v_3 vibrational mode emission band centered at 4.26 microns and the CO gas vibrational mode emission band centered at 4.67 microns, which will allow detection of a comet's combined $CO+CO_2$ gas coma. This method of detecting such cometary volatiles via broadband imaging has had much success in the past with Spitzer (e.g. [4, 9]) and WISE/NEOWISE (e.g. [10, 11]). The longer wavelength NC2 images of comets will measure thermal emission from nuclei and dust. Because of the particular bandpasses of NC1 and NC2 we are currently focusing on developing methods of modeling cometary activity behaviors utilizing derived (1) nuclei cumulative size distributions, (2) dust activity behaviors as characterized by empirical trends of the εfρ parameter and (3) CO and CO_2 gas comae trends based on the previously mentioned past and ongoing surveys. Future efforts by the NEOSM Investigation Team will focus on incorporation of other characteristic cometary phenomena (e.g., dust tails and trails) to help refine expected detection efficiencies and coma and/or tail flux removal for robust nucleus size estimation.

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References

[1] Lilly (Schunova) et al., 2020, AAS Meeting Abstracts, 385.04.

[2] Lisse et al., 2002, IAU Colloq. 181, Vol. 15, 259.

[3] Ootsubo et al., 2012, ApJ, **752**:15.

[4] Fernandez et al., 2013, Icarus, **226**, Issue 1.

[5] Denneau et al., 2013, PASP, **125**:926.

[6] Masci et al., 2019, PASP, **131**:995.

[7] Tonry et al., 2018, PASP, **130**:988.

[8] Mainzer et al., 2011, ApJ, **731**:53.

[9] Kelley et al., 2013, Icarus, **225**:475.

[10] Bauer et al., 2015, ApJ, **814**:85.

[11] Bauer et al., 2017, AJ, **154**:53.