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Modeling the photometric behaviour of comet populations

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Abstract

Predictions of cometary magnitudes are a critical portion of the development of a model solar system that can be used to verify and validate the performance of future survey missions. While the number of known Near-Earth Comets (NECs) is substantially smaller than the number of Near-Earth Asteroids, these icy bodies still present a significant impact hazard to the Earth. The known NECs come from all classes of comets, including Jupiter Family Comets (JFCs), Halley Type Comets (HTCs), and Long Period Comets (LPCs). Due to the volatile nature of the materials which define comets, their magnitude does not follow a straightforward brightening trend such as is found for asteroids. The behavior of the outgassing of volatile species (including H_2O, CO_2, and CO) and the dust that is lifted off the comet's surface by these volatiles must be modeled in order to make accurate predictions of the comet's magnitude as it orbits the Sun. While the activity of comets is notoriously difficult to predict for individual objects due to the possibility of outbursting and seasonal events, the behavior of comets as an ensemble population is a somewhat more tractable problem. Predictions of cometary magnitudes will be folded in to the Reference Small Body Population Model (RSBPM) that is being developed by the Near-Earth Object Camera (NEOCam) team which can be used to verify and validate the performance of future survey missions and allow for debiasing of the observed comet populations [1].

With the recent increase in the number and depth of all-sky surveys (e.g, PANSTARRS [2], Zwicky Transient Facility [3], ATLAS [4], WISE/NEOWISE [5]), cometary activity is being monitored on an unprecedented scale. We are now able to monitor the behavior of individual comets at a regular cadence over the course of several months in order to better characterize levels and types of activity. However, cometary behavior is well known to be unpredictable for individual comets, and even to vary for a single comet from perihelion to perihelion. The results of surveys which monitor a large number of comets can be used to smooth over this variability and allow us to begin to develop a model for cometary behavior that can be use on the population-wide level.

The currently running surveys are providing an excellent base on which the next-generation wide field surveys (e.g., NEOCam [1] and the Large Synoptic Survey Telescope [LSST] [6]) can be built. Since NEOCam will be a space-based telescope, the spacecraft and on-board instruments must be optimized prior to launch. In order to ensure that NEOCam will perform as expected, the team is developing the RSBPM which can be used to predict the expected performance pre-launch and verify the performance post-launch. That is, by modeling the expected brightness of the comet population, we can make predictions regarding how many comets we would expect to see with NEOCam, and what they would look like in the data. Once the survey begins, we can then compare these predictions to the actual measurements to calculate the efficiency of the survey, and thus de-bias the survey to properly characterize the comet population.

Since the surveys that provide the data for the models are ongoing, the input data set for our models is still being built up. We present here a first look at the process that we will use to characterize the population-wide behavior of cometary activity which will be folded in to the RSBPM.

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