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# Sidereal Periods, Pole Solutions, and Shape Models of Saturn's Irregular Moons

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During the Cassini mission, the irregular moons of Saturn [1] have been targeted more than 200 times for remote observations, marking the first exploration of irregular moons through an interplanetary spacecraft orbiting the common planet [2]. The moons have been observed with the Narrow Angle Camera (NAC) of Cassini's ISS instrument which was a spacecraft-fixed Ritchey-Chretien reflector telescope with a focal length of 2 m and an aperture of 0.19 m [3]. Since the irregulars were (except for Phoebe during a targeted flyby) always more than $4 \cdot 10^6$ km and mostly even more than $10^7$ km away from the spacecraft and thus too far away for disk-resolved imaging, the goal was to obtain lightcurves through disk-integrated photometry.

From the data, 25 rotation periods could be derived, 24 of them were previously unknown [2]. A valuable property of the data set is the large range of observation phase angles. Most of the observations were intended for determination of sidereal periods, pole-axis directions, phase curves, and possibly convex-shape models and rough estimates of object sizes and hemispheric color variations. About 20,000 images from over 160 different observations, obtained for 13 different irregular moons at phase angles between 1° and 143°, have been calibrated and measured for this purpose.

For ISS data calibration the stock dark frames used in the standard CISSCAL pipeline [4] [5] proved to be inadequate. Because of the long exposure times required for those observations, any difference in the actual detector dark current with respect to the stock dark frames acquired many years earlier would produce intolerable additional noise. Furthermore, due to platform stability control deadbanding, observed objects moved back and forth on the CCD over a range of 10-20 pixels with typical periods of tens of minutes. For this reason undercorrected pixels would also contain an additional quasi-periodic noise signal. Therefore, we decided to use science observations taken close in time to the actual observation to produce updated dark frames for each individual observation.

Color data calibration will be done in a similar way. In addition, making use of data from Cassini-ISS observations of solar-analog stars 16 Cygni B and HD71334 is planned.

The irregular moons were observed at multiple geometries, resulting in very different illumination conditions, phase angles, aspect angles, and sub-spacecraft directions. So far, many lightcurves were found that appear very asymmetric, often including 3 maxima and 3 minima (Fig. 1, 2), but not necessarily (Fig. 3). This is work in progress; with the complete analysis of the data set, we plan to compare the pole directions, the different shapes, the reference phase curves and the colors of the moons to each other as well as to other Solar System objects like TNOs, Trojans, and main-belt asteroids.

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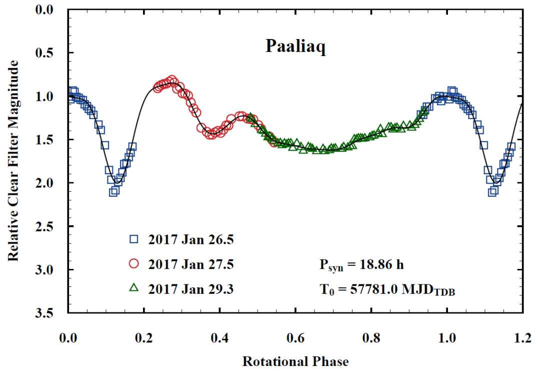


Figure 1: Lightcurves of Paaliaq from three observations in January 2017 at ~110° phase.

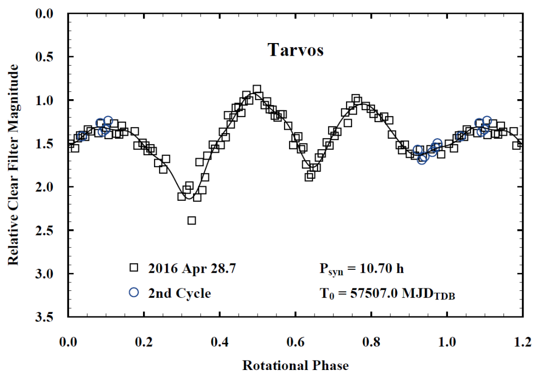


Figure 2: Lightcurve of Tarvos from April 2016 at 109° phase.

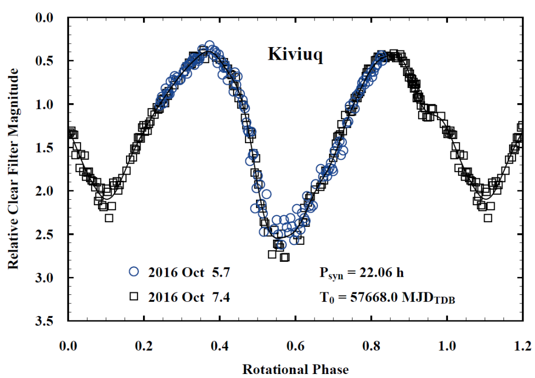


Figure 3: Two lightcurves of Kiviuq from October 2016 at 112° phase.

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