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First Shape Model of Asteroid (704) Interamnia From the VLT/Sphere AO Observations

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Introduction

The B-type asteroid (704) Interamnia, although a sixth largest main-belt objects by size, does not yet have a reliable spin state and shape model solution. This is mostly because it has a low lightcurve amplitude and a rather limited dataset of optical data. We resolved this issue by coordinating a large photometric campaign.

However, our initial motivation for studying Interamnia was different – due to its large angular size as observed from the Earth, it became a target of our ESO large program (PI: P. Vernazza; ID: 199.C-0074) aiming at acquiring high angular images of ∼40 asteroids larger than 100 km throughout their rotation (starting April 2017).

The high angular resolution of the new-generation visible adaptive-optics camera SPHERE/ZIMPOL mounted on the ESO/VLT telescope on Cerro Paranal offers a unique opportunity to study asteroid topography and shapes in great details with the ground-based observations [V18]. Currently, only in-situ observations by space probes can provide better images.

Data

We compiled a large dataset of 188 optical lightcurves sampling 15 different apparitions. These data include lightcurves downloaded from the Asteroid Photometric Catalog and the SuperWASP archive [G17], obtained by Brian Warner [W18], Trappist North and South telescopes, and also from the observing campaign supervised by GaiaGOSA (`www.gaiagosa.eu`).

Six epochs of Interamnia well spaced in the rotation phase were observed with the SPHERE instrument [B08] between August and October 2017, and another six epochs then between December 2018 and January 2019. The angular size of Interamnia varies between 0.20–0.26". For the epoch when Interamnia is the closest to the Earth (1.78 au), one pixel represents ∼4.6 km, which allows us to reliably detect surface details as large as ∼40 km.

Methods

We apply the convex inversion procedure of [K11a] and [K11b] to the dataset of disk-integrated optical lightcurves to derive the spin state solution. This widely used method (e.g., [H11,D16]) makes use of the photometric data covering a large number of observing geometries to constrain the sidereal rotation period, position of the spin axis and the convex shape. Once the rotation state is known, it can be used as a necessary input for the ADAM inversion algorithm [Vi15,Vi16] that takes optical lightcurves, stellar occultations and disk-resolved images into consideration when reconstructing the 3D shape model with local topography.

Results and conclusions

The large photometric dataset significantly enhanced by our observing campaign allowed us to derive the first reliable spin state solution and a rather spherical shape model of Interamnia. Moreover, we also applied the ADAM algorithm to the combined optical and disk-resolved data and obtained a detailed 3D shape model with local topography of asteroid Interamnia (Fig. 1). Moreover, we also estimate the size

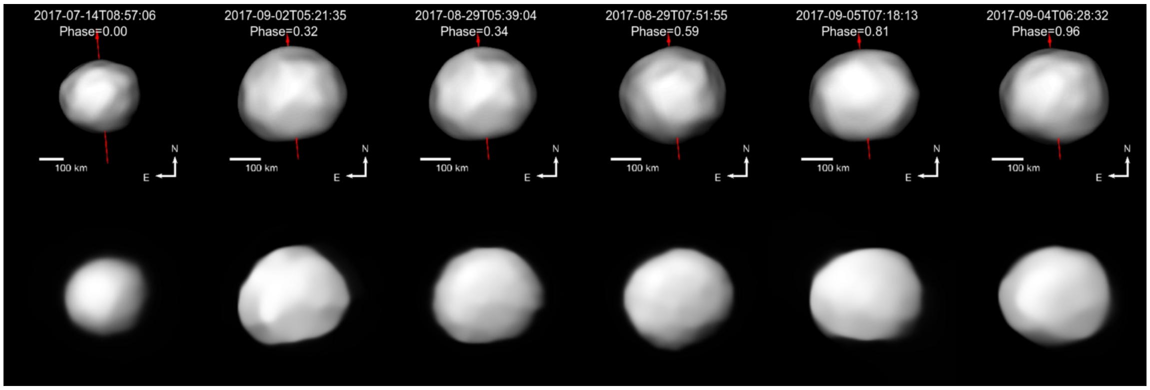

Figure 1: Different orientations of the shape model of Interamnia (*Top panel:*) reconstructed from the optical lightcurves, stellar occultations and VLT/SPHERE images (*Bottom panel*). The red line indicates the position of the spin axis with the ecliptic longitude $\lambda = 88°$ and latitude $\beta = 62°$. We show epochs from the 2017 apparition.

and bulk density of Interamnia.

The shape model of Interamnia is rather round lacking any large scale concavities or even topographic features such as impact craters although we should be able to resolve those as large as $\sim$40 km. The sphericity (i.e., the ratio between the surface of a sphere with the same volume as the shape model and the surface of the shape model) of Interamnia's shape model is similar to values for Vesta and Pallas [V19a,V19b,M19] and much higher than for Iris [H19] or Psyche [Vi18], thus bodies with significantly higher bulk density but only slightly smaller mass. Furthermore, by comparing the global shape model of Interamnia to other asteroids in the size range of $\sim$200–500 km, we will tackle the question at which size the bodies start to deviate from the hydrostatic equilibrium and whether this is dependent on the composition.

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