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VLT/SPHERE looks at triple asteroid Sylvia

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Abstract

We present high-angular resolution images of the triple asteroid system (87) Sylvia, Romulus, and Remus obtained with the SPHERE/ZIMPOL instrument at the ESO VLT. The images, combined with historical optical lightcurves allows to reconstruct the 3-D shape of Sylvia. The precise astrometry of the two satellites in the SPHERE/ZIMPOL images, combined with tens of measurements performed on archival VLT/NACO, Keck/NIRC2, Gemini/NIRI images allows to determine minute orbital elements for the two satellites and to constraint the mass of Sylvia. From our measurement, we determine the density of Sylvia. We will discuss the topography of Sylvia, the dynamical properties of the system, and the implications of its density.

1. Introduction

Sylvia is the first triple system discovered in the asteroid belt, with its two satellites Romulus and Remus (Marchis et al., 2005). As such, many high-angular resolution images were acquired by several groups with the VLT/NACO, Keck/NIRC2, and Gemini/NIRI facilities. These observations provide a rich data set to study the dynamics of the satellites over many years. Several authors reported on the detection of the gravitationnal quadrupole (J_2) of Sylvia (Fang et al., 2012; Beauvalet & Marchis, 2014), while Berthier et al. (2014) reported on a purely Keplerian orbit implying a very low J_2. Although not solved, this issue has far-reaching implications on the internal structure of Sylvia, linked with its formation history: homogeneous or differentiated with a denser core (Neveu & Vernazza, 2019).

2. Observations

We observed the P-type (87) Sylvia as part of our Large Program at the European Southern Observatory (ESO) Very Large Telescope (VLT) with the adaptive-optics (AO) fed SPHERE/ZIMPOL instrument (Beuzit et al., 2008). This survey (PI: P. Vernazza; ID: 199.C-0074) aims at acquiring high-angular images of about 35 asteroids larger than 100 km throughout their rotation to study the 3D shape and cratering history (Vernazza et al., 2018; Hanuš et al., 2019), and their density from mass estimates from the literature or from the presence of satellites (Viikinkoski et al., 2018; Carry et al., 2019).

3. Results

Combining the SPHERE/ZIMPOL images with tens of optical lightcuves with the `ADAM` algorithm (Viikinkoski et al., 2015), we reconstruct the 3D shape of Sylvia (Fig. 1). Sylvia is a large 280 km asteroid, strongly deviating from an oblate spheroid with a clear elongation along its equator (equatorial axes ratio of about 1.4). Its topography reveals the presence of several depressions reminiscent of large impact craters such as the one that created the dynamical family linked with Sylvia (Vokrouhlický et al., 2010).

We measure 130 positions of the largest satellite, Romulus, and 67 of Remus from 2002 to 2018. We determine their orbits with the `Genoid` algorithm (Vachier et al., 2012) to be prograde, coplanar, and equatorial. The mass of Sylvia is estimated to $\approx 1.4 \times 10^{19}$ kg, implying a low density of 1.2 ± 0.1 g·cm^{-3}. This values is however higher than the P-types Trojans (617) Patroclus and (624) Hektor (Marchis et al., 2006, 2014).

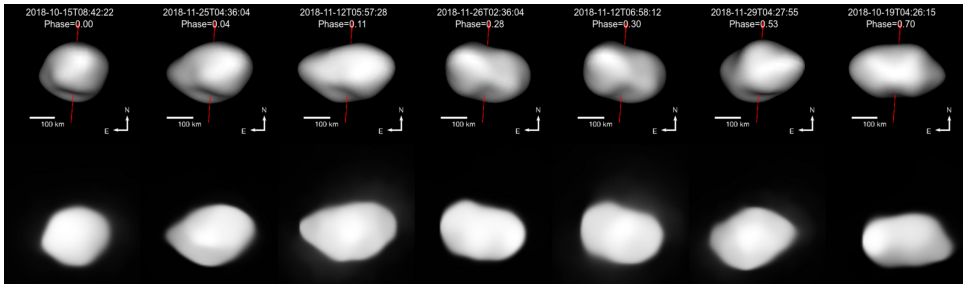

Figure 1: Comparison of the SPHERE/ZIMPOL AO images (bottom) with the shape model (top) of Sylvia.

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