The Centaur (10199) Chariklo and its ring system through stellar occultations.

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The Centaur (10199) Chariklo is a small body moving in an elliptical orbit, between Saturn and Uranus, with heliocentric distances ranging 13.1 and 18.9 au. It is the largest object known in this orbital region, and since its discovery in 1997 (Ticha et al. 1997), many studies tried to characterise this object. From the literature, different observational techniques give an equivalent surface radius ranging between 109 and 151 km (Sekiguchi et al., 2012; Lellouch et al., 2017). Additionally, a ring system was detected by Braga-Ribas et al. (2014) using stellar occultation data sets acquired in 2013. Between 2013 and 2016, other stellar occultations brought more detailed information on this system (Bérard et al., 2017; Leiva et al., 2017; Bérard et al., 2017; Santos-Sanz et al., 2021).

A stellar occultation occurs when a solar system object passes in front of a star for an observer on Earth. Using this technique it is possible to determine sizes and shapes at kilometre precision and to obtain other physical parameters, such as its albedo, the presence of an atmosphere, rings, jets, or topographic features (Braga-Ribas et al., 2013, 2019; Dias-Oliveira et al., 2015, 2017; Benedetti-Rossi et al., 2019; Ortiz et al., 2017; Leiva et al., 2017; Bérard et al., 2017; Santos-Sanz et al., 2021).

After the release of the Gaia DR2 catalogue (Gaia collaboration et al., 2018), the stars' positions are known with uncertainties below one milliarcsecond (mas). Moreover, after successful stellar occultations observations, Chariklo ephemeris was updated, now it has uncertainties below five mas ($\sim$50 km at Chariklo's distance). Accurate star's positions and updated ephemeris resulted in successful observational campaigns in Namibia (22/06/2017), South America (23/07/2017) and La Réunion (08/08/2019). These were the first Chariklo occultations with more than three chords across the main body. These events increased our knowledge about Chariklo's shape, and this information can be used to constrain the dynamic of its rings. Six other events were observed between 2017 and 2020, however with fewer detections on the main body.
In this work, we will present the obtained results, such as the global shape of Chariklo's rings system, including its pole determination, the ring width variation, structures within the rings (see Figure 1), the width of the gap between C1R and C2R and limits for the ring eccentricity and particle's sizes. Also, the 3D shape of Chariklo was obtained from eleven stellar occultations observed between 2013 and 2020 (see Figure 2). The parameters obtained in this work should be useful for constraining dynamical models of Chariklo and its rings and provide new insights into the formation and evolution of this system.

**Figure 1:** Results of the 2017-07-23 event. The central plot displays the occulting chords projected in the sky-plane for the main body (in blue), C1R (in green), and their uncertainties (red segments). The black line is the best-fitting ellipse to the C1R point. The side panels display the normalised radial ring profiles, projected in the ring-plane, numbered as follows: VLT at Cerro Paranal (1), Tolar Grande (2), La Silla (3), Observatório Pico dos Dias (4) and Cerro Tololo (5). The observations on La Silla were made using the Danish telescope dual experiment in the Visual (3.1) and Red bands (3.2) and a 1-meter telescope (3.3). The observations on Cerro Tololo were grazing over C1R and they were made using the SARA (5.1) and PROMPT (5.2). We call attention to the unambiguous detection of W-shaped structures within the C1R.
Figure 2: Ellipsoidal model that best fits the 11 stellar occultations observed between 2013-06-23 and 2020-06-19. Each panel corresponds to an occultation event identified by the time stamp in the upper part of each one. The blue lines stand for the observed chords with their uncertainties in red. The black dot indicates the intersection between the equator and the prime meridian, which is used as the reference to define the rotation angle.

References:

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