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Chiron, another Centaur with ring material

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Abstract

Chariklo is known to possess an exotic ring system and we show indications from several distinct data sets that Chiron also has a ring system with similar features to that of Chariklo, although its case is somewhat more complex because Chariklo has never shown cometary-like activity, whereas Chiron has.

1. Introduction

After the finding (through a stellar occultation in 2013) that a body of non-planetary dimensions named Chariklo has a dense ring system of two narrow and dense rings separated by a gap [1], we wondered whether other solar system bodies similar to Chariklo could have rings. It turns out that Chiron, another Centaur similar to Chariklo in size also shows clear indications that it could have a ring system. As recently reported [2] there are observations of past stellar occultations caused by Chiron in which there are sudden and brief brightness decreases nearly identical to those caused by the rings of Chariklo, but they had not been attributed to rings. The sudden brightness drops had been interpreted as due to a dust jet [3,4,5], probably because the occultations were not recorded from several observatories, in contrast to the Chariklo occultation in 2013, which was widely observed.

2. Reanalysis of past occultations

The occultation by Chiron in 2011 is the one that more closely resembles that of Chariklo, but only two chords were obtained [5]. Using the times when the sudden brightness drops occurred to plot the events in the plane of the sky, and putting the additional constraint that the rings ellipse and the ellipse that represents the projected shape of Chiron are concentric, the rings orientation can be derived [2]. The two possible orientations are consistent with earlier occultation events although the rings material is not homogeneously distributed and seems to be absent at certain longitudes.

3. Another indication: Long term brightness changes

Chiron's brightness variations along four decades can be explained, overall, by the presence of a reflecting ring system that contributes nothing to Chiron's brightness when the system is edge-on with respect to the Earth observers, while currently a considerable fraction of Chiron's brightness comes from the rings. The orientation of the ring system that can explain the historical time series is coincident with the orientation derived from the reanalysis of the stellar occultations.

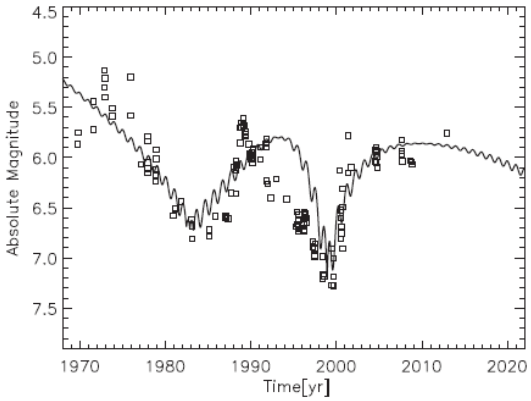

Figure 1. Solid line: Model to explain Chiron's overall absolute magnitude in V band whose key feature is the incorporation of a ring system [2]. The square symbols are the observations.

4. Another indication: Water ice spectroscopic features

The variable water ice spectroscopic feature in Chiron, which depends on the epoch when it was observed [6], can be explained if Chiron's water ice is in the rings. This can even explain the total disappearance of the water ice feature in 2001 reported in [7], because in 2001 the ring system was close to the edge-on position. All this makes sense and is exactly the same as observed for Chariklo, whose water ice is in the rings [8]. We know that Saturn's rings are rich in water ice while the cometary surfaces, the closest analog to Centaur surfaces, are devoid of spectroscopic water ice features. Hence, it appears natural that the water ice feature comes from the rings.

5. Another indication: rotational lightcurve amplitude change

There is yet more evidence for a ring system. The amplitude of the rotationally-induced oscillation of Chiron's brightness has been changing over the years. A simple model that uses the rings system orientation derived above and that incorporates the brightness of the rings, can explain the observed changes (Fig. 2).

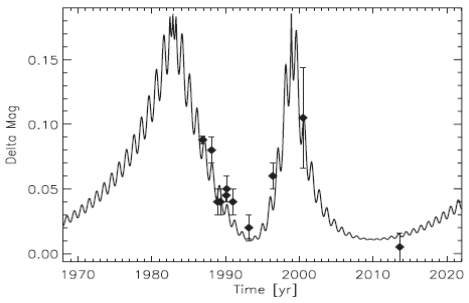

Figure 2. In continuous line we show a model of the change in the amplitude of Chiron's rotational brightness oscillation. This model incorporates the orientation of the ring determined from the occultation. The filled diamonds represent the observations. As can be seen, the fit is remarkably good.

6. More indications

The albedo of the ring system used in the brightness and spectroscopy models is identical. And the ring systems in Chariklo and Chiron have very similar optical depths and sizes, with even a gap of similar size in between. All these coincidences point to a similar origin. Besides, the alternative explanation of a jet or shell for Chiron's brightness drops does not hold because the jet or shell would have to have exotic properties. On the other hand, there was no activity that could sustain a jet or shell at the epochs when the occultations were recorded.

7. Discussion

The origin of the rings in these bodies is not yet clear. There have been different scenarios proposed and their implications for our understanding of the solar system are important and diverse. Some of these are discussed in some detail in [2], where several speculations and ideas have been presented.

References

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