

(3200) Phaethon: asteroid or comet?

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Abstract

A multi-colour phase - polarization curve of asteroid (3200) Phaethon has been obtained during the December 2017 apparition by merging measurements taken at the observing station of Calern (France) and at the Rhoden observatory (Bulgaria). The measured values of linear polarization are among the highest ever observed for a Solar system body. The P_{max} parameter seems to occur at a phase angle around 130° and reaches more than 45%. Phaethon is the parent body of the Geminid meteor shower, and the real physical nature of this object (asteroid or comet?) has been a long-debated subject. Our polarimetric measurements suggest that Phaethon is an asteroid, rather than a comet, and is likely a former member of the dynamical family of (2) Pallas.

1. Introduction

(3200) Phaethon is a near-Earth asteroid belonging to the Apollo orbital subclass, and is a very interesting object due to a number of peculiar properties.

1. It has a very high orbital eccentricity (0.89), and a correspondingly small perihelion distance of only 0.14 AU.
2. It is thought to be the parent body of the Geminid meteor shower.
3. In terms of spectral reflectance properties it belongs to an unusual taxonomic class.

In particular, it was classified by [1] as a member of the rare F taxonomic class, whose members are low-albedo objects that in at least one case (the asteroid (4015) Wilson Harrington) have exhibited in the past some cometary activity. The F class is no longer present in the most recent classifications, because it was characterized by its behaviour at blue wavelengths, that are no longer covered in modern spectroscopic survey. On the other hand, [2] published

a reflectance spectrum suggesting that Phaethon does not belong to the F taxonomic class. As we extensively explained in a very recent paper [3], the investigations carried out by different authors, based on spectroscopic and dynamical evidence, has not been so far sufficient to draw definitive conclusions about the real nature of Phaethon.

2. Polarimetry as a useful tool

A very interesting result of asteroid polarimetry is that the objects belonging to the old F-class display some unusual properties in their phase-polarization curve, which are sufficient to identify them as a separate class. In particular, the most important characteristic is a low value of the so-called inversion angle of polarization, that is the value of phase angle at which there is the transition from observing conditions in which the plane of linear polarization of the asteroid's light is found to be parallel to the Sun-observer-target plane (scattering plane) to observing conditions in which the plane of linear polarization is found to be normal to the scattering plane. Interestingly enough, the same property displayed by F-class asteroid has been found to be also exhibited by some cometary nuclei (see references in [3]). This opens the perspective of determining the physical nature of Phaethon (asteroid or comet) by means of an analysis of its phase-polarization curve. For this reason we organized a campaign of polarimetric observations of (3200) Phaethon during its last apparition in December 2017.

3. Results

We observed (3200) Phaethon in BVRI colours using the C2PU facilities of the Calern observing station of the observatory of Nice (France) and in R colour using the 2-m telescope of the Rhoden observatory (Bulgaria). Our polarimetric observations covered a very wide interval of phase angles, all of them belonging to the positive polarization branch, where the linear polarization plane is found to be normal to the scattering

plane. One should not that the high values of phase angle of our observations were made possible by the fact that Phaethon is a near-Earth asteroid, and could be observed when being at a short distance from the Earth, in a wide and rapidly changing interval of observing conditions.

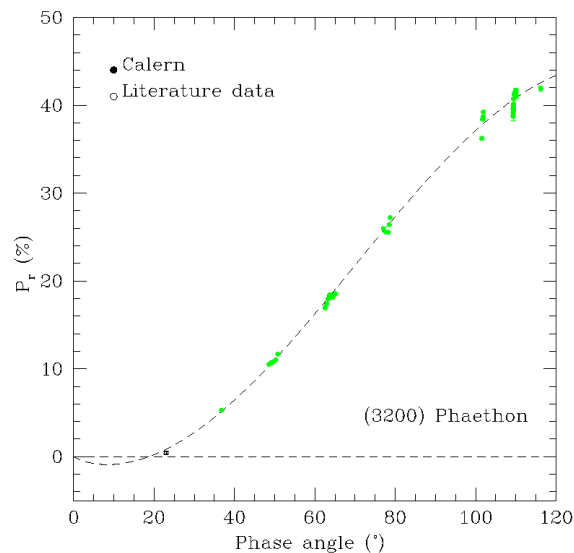


Figure 1: Phase - polarization curve of (3200) Phaethon in V light. The green symbols indicate the results of our measurements. One single previous measurement available in the literature is indicated by a black symbol.

The results of our observations can be summarized as follows:

1. We have measured the highest values of linear polarization ever found for objects of the solar system.
2. We derive an estimate of the P_{max} polarimetric parameter, namely the maximum value of polarization attained in the positive polarization branch. The obtained value suggests a very low value for the geometric albedo.
3. The phase - polarization curve of (3200) Phaethon seems to be poorly compatible with the F-class. Conversely, a much better agreement is found with the polarimetric properties of (2) Pallas. This confirms previous suggestions of [4] who suggested that Phaethon could be an evolved member of the Pallas' dynamical family.

4. Summary and Conclusions

We plan to obtain further polarimetric observations covering also the negative polarization branch during the next apparition of this asteroid. This will allow us to obtain definitive conclusions about its incompatibility with the polarimetric behaviour of the F-class, and its resemblance with the polarimetric properties of (2) Pallas.

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