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The unusual properties of (101955) Bennu, as found by OSIRIS-REx, were not unexpected

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Abstract

The rendez-vous mission of the OSIRIS-REx space probe with the near-Earth Asteroid (101955) Bennu has revealed very interesting properties. The first spectroscopic and near-IR data from the spacecraft instruments led to the discovery of clear evidence of hydration of the surface minerals. Later, followed the discovery of frequent events of ejection of plumes of dust ("Bennu's dust spitting") from the surface. These discoveries, although quite spectacular, were not totally unexpected. Well before the arrival of OSIRIS-REx, ground-based polarimetric measurements allowed us to conclude that Bennu belongs to a rare class of asteroids including objects sharing some polarimetric properties with bodies displaying cometary activity.

1. Introduction

Among the most important discoveries made in the field of polarimetry of small solar system bodies, there is the discovery that linear polarisation measurements of asteroids can be used to distinguish between objects that were classified as member of the old F-taxonomic class in the 80s, among those currently classified as B-class. This is because the objects previously classified as F-class are characterized by unusually low values of the so-called inversion angle of polarisation. This is the value of the phase angle (the angle between the directions to the Sun and to the observer, as seen by the target object) for which the plane of linear polarisation of the sunlight scattered by the surface makes a 90° jump in its orientation [2, 1]. This allows us to distinguish between F- and B-class asteroids in the current era, since the differences between the two classes, which were previously found to concern the spectral reflectance behaviour in the blue region, are no longer seen in modern asteroid spectroscopy. The reason is that modern spectroscopic surveys have been making use so far of instruments that very rarely provide a sufficient coverage of the spectrum at short wavelengths (we expect that in the near future, the Gaia mission of the ESA will produce an improvement of the situation, in this respect). It is important to note that the same unusual polarimetric behaviour of F-class objects was found to be shared by objects including comets and asteroids exhibiting episodes of cometary activity (see, for instance, [4]).

2. The case of (101955) Bennu

We proposed to carry out VLT polarimetric observations of (101955) Bennu, the target of the OSIRIS-REx space mission, when we realized that this asteroid had been classified as a member of the modern B-taxonomic class. We were aware that such a classification could have been "hidding" the fact that this asteroid could be a new member of the nowadays largely forgotten F-class. If this was the case, Bennu might be even more interesting than previously believed, and could exhibit some weak cometary activity that only an in situ exploration could detect. Moreover, Bennu is the asteroid for which the most accurate measurement of an orbital Yarkovsky acceleration has been obtained. Of course, if the dynamics of Bennu could be influenced by some kind of cometary activity, the interpretation of its orbital evolution in terms of pure Yarkovsky effect could be questioned. Even in the absence of any recognizable cometary activity, it could be possible that a low-albedo near-Earth asteroid as Bennu could be the current stage of a long orbital evolution that could have moved a primitive body rich in volatiles from the outer solar system to its current orbit. The existence of the so-called main belt comets suggests that the traditional distinction between asteroids and comets is not so sharp as believed in the past. If Bennu was found by means of polarimetry to be an F-class asteroid, then the future OSIRIS-REx data could be expected to reveal some possible evi-

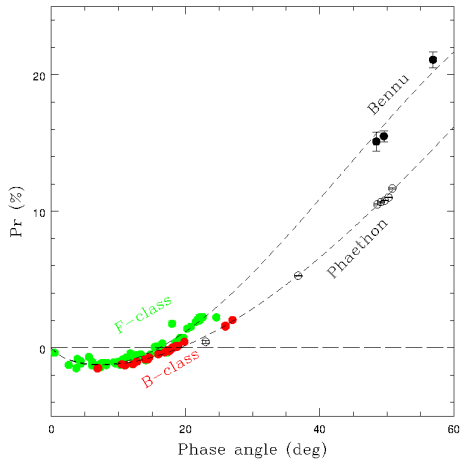

Figure 1: Phase polarization curves of F-class asteroids plus (101955) Bennu (green symbols plus black full circles, respectively) and of (2) Pallas plus (3200) Phaethon (red symbols plus open circles, respectively). The best-fit curves for the two data-sets are shown as dashed lines. The polarization data of (101955) Bennu at large phase angles reach values much higher than in the case of (3200) Phaethon. Bennu data correspond to a credible extrapolation of existing phase-polarization data for the F-class, whereas Phaethon data are in much better agreement with the phase-polarization data for (2) Pallas, the largest B-class asteroid.

dence of episodes of surface activity.

Our VLT polarimetric observations have fully confirmed that (101955) Bennu is a member of the F-taxonomic class. Fig. 1 shows that the linear polarization of Bennu at large phase angles reach unprecedentedly high values, which seem to be fully compatible with an extrapolation of the behaviour of F-class asteroids belonging to the asteroid main belt. Unlike Bennu, these asteroids cannot be observed at high phase angles. The values of linear polarisation of Bennu are much higher than those obtained in a previous observing campaign for another F-class candidate, (3200) Phaethon, which was instead found to be more compatible with the behaviour of the B-class, and was interpreted as a possible fugitive from the dynamical family of (2) Pallas [4].

The results of our investigation were published well before the arrival of OSIRIS-REx to (101955) Bennu [3]. The results of OSIRIS-REx, with the discovery of evidence of hydrated minerals on the surface, and, even more, with the discovery of "dust spitting" from the surface, have fully confirmed our expectations.

3. Summary and Conclusions

The recent results of the in situ exploration of (101955) Bennu cannot be defined as "totally unexpected". They are a spectacular demonstration of the predictive power of asteroid polarimetry. This technique, through the determination of the polarisation inversion angle, is a major tool for a timely identification of asteroids having histories characterized by episodes of cometary activity.

Acknowledgements

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