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Space weathering of asteroids as observable with GAIA

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Abstract

Among the scientific objectives of the GAIA mission, there is great scientific interest in detecting asteroids and comets in our Solar System. In the next years, GAIA is expected to strongly contribute to this search because of its unprecedented sensitivity to faint, moving objects. We investigate how to use the spectrophotometric data of asteroids that GAIA is in the process of acquiring (scientific mission started in summer 2014 for 5 years) to evidence space weathering processes.

Along with asteroid spectral reflectivities, one of the products are the Spectra Shape Coefficients, a sort of colours obtained by integrating the spectra in predefined bands.

To this end we have checked which colours, among those chosen by the GAIA team as wavelengths for the spectral shape coefficients, can be more useful to evidence the spectral alteration induced by space weathering as simulated in the laboratory by irradiation with energetic ions and pulsed lasers.

We show that a diagram plotting the colour index SSC_{530}-SSC_{953} vs the SSC_{752}-SSC_{953} one, well defines a region where the GAIA observations of S-type asteroids and Vestoids can evidence the space weathering experienced by the observed objects.

1. Introduction

The surfaces of atmosphere-less bodies are irradiated by a large variety (in terms of energy and mass) of cosmic and solar wind ions, by UV photons, and collide with interplanetary dust. These effects are globally known as "space weathering" and have been evidenced on several asteroid types on the basis of laboratory studies on terrestrial silicates and meteorites (for a recent review see [1]).

An enormous advance in the understanding of asteroid space weathering may come from the Gaia mission (ESA) that is surveying the entire sky and it is expected to observe about 400,000 asteroids, for which high precision astrometry and photometry will be obtained [2]. It has been estimated that a spectral characterization will be obtained for at least 100,000 asteroids from the low-resolution spectra (0.35-0.95 μm) obtained by Gaia [3].

Here we discuss how to use the spectrophotometric data of GAIA to evidence space weathering of S-type asteroids and Vestoids. Our investigation is based on many experimental data we have collected in the laboratory after ion bombardment of terrestrial silicates and meteorites [4, 5] or pulsed laser irradiation [6] or even from RELAB database [7]. We show that GAIA observations may be used to provide a deeper and statistically stronger view of asteroid weathering.

2. Spectral analysis

The GAIA spectrophotometers are based on two low-resolution prisms, one (BP) is optimized for the "blue" wavelengths (330–680 nm) and one (RP) for the "red" wavelengths (640–1000 nm).

Eight spectral shape coefficients (SSC) have been suggested to characterize at the best the spectral response of the two filters. These SSCs are peaked at 380, 467, 530, 639, 668, 752, 824 and 953 nm (see Figure 7 in [3]). We have measured the reflectivity of our laboratory samples at these wavelengths before and after energetic processing, to find the best colour indexes that evidence the effect of the processing. As an example we show the spectra of a bulk sample of the meteorite Kosice before and after ion irradiation (Fig. 1). Also indicated in the figure are the positions of the three wavelengths (corresponding to the

wavelengths of three of the SSCs listed above) that we use to determine the two color indexes found to best represent the effects of space weathering. These indexes are SSC530-SSC952 and SSC752-SSC952.

The two color indexes measured for several samples of silicates and meteorites irradiated by energetic ions or laser pulses are plotted one vs. the other in Fig. 2. It is evident from the figure that there is a trend for all samples to exhibit color indexes that increase because of the energetic processing. The increase in the SSC_{530}-SSC_{952} color index testifies for the reddening of the sample [5], the increase of the SSC_{752}-SSC_{952} one reflects the monotonic decreases of the 1 μm band with ion bombardment [4].

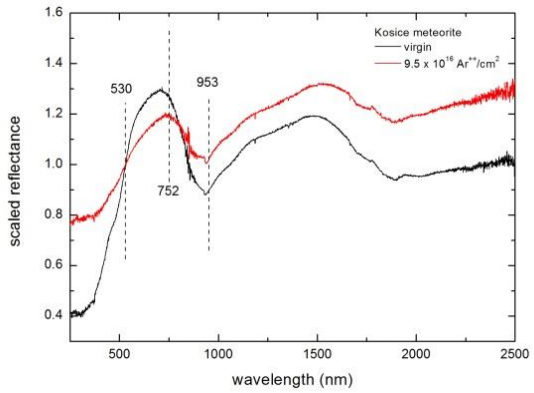

Figure 1: Scaled (to 530 nm) reflectance spectra of a bulk sample of the meteorite Kosice before and after ion irradiation.

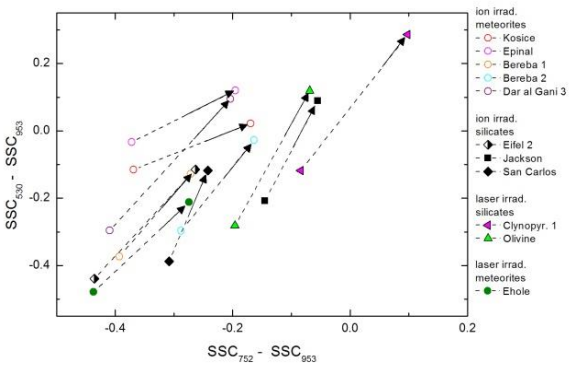

Figure 2: The colour index SSC_{530}-SSC_{952} is plotted vs the SSC_{752}-SSC_{952} one. The data refer to samples of silicates and meteorites irradiated by energetic ions or laser pulses (arrows indicate the increasing dose).

Conclusion

In this work, we discuss how the data provided by the GAIA mission may be used to evidence space weathering of S-type asteroids and Vestoids. Our investigation is based experimental data we have collected in the laboratory after ion bombardment of terrestrial silicates and meteorites, pulsed laser irradiation, or even from RELAB database.

We show that GAIA observations may be useful to provide a deeper and statistically stronger understanding of asteroid space weathering.

Acknowledgements

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