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# Near-infrared spectroscopic survey of B-type asteroids: compositional analysis

**J. de León** (1), N. Pinilla-Alonso (2,3,4), J. Licandro (5,6), H. Campins (7) and G. A. Marzo (8)

(1) Instituto de Astrofísica de Andalucía – CSIC, Granada, Spain (jleon@iaa.es / Fax: +34-958-814530), (2) SETI Institute, California, USA, (3) INCT-A, Sao Paulo, Brasil, (4) Observatório do Valongo, Rio de Janeiro, Brasil, (5) Instituto de Astrofísica de Canarias, Tenerife, Spain, (6) Departamento de Astrofísica – ULL, Tenerife, Spain, (7) University of Central Florida, USA, (8) ENEA, C. R. Casaccia, Roma, Italy.

## Abstract

We present near-infrared spectra of 23 B-type asteroids obtained with the NICS camera-spectrograph at the 3.56 m Telescopio Nazionale Galileo. We also include visible and near-infrared spectra of 20 additional B-type asteroids from the literature, including near-Earth asteroid 1999 $RQ_{36}$, primary target of NASA´s OSIRIS-Rex sample return mission. A plot of the spectra of all the asteroids shows a continuous trend in the near-infrared between red and blue slopes. We apply a clustering technique to reduce the volume of data to six "average spectra" or "centroids" representative of the whole sample. These spectra are then compared against the entire RELAB database to search for best analogs.

## 1. Introduction

B-type asteroids are mostly found in the middle and outer main belt, and are believed to be primitive, low-albedo, and volatile-rich asteroids. According to [1], spectra in the visible and near-infrared range of B-types can be distinguished into three main groups: those similar to the spectra of (2) Pallas, those similar to (24) Themis, and the rest, each group having their particular set of meteorite best analogs among the carbonaceous chondrites. Primitive asteroids, including B- and C-types, have relevance nowadays, not only for the new findings in terms of surface composition ([2],[3]), but also because they are selected as primary targets of sample return space missions, like NASA´s OSIRIS-Rex ([4]) and ESA´s Marco Polo-R ([5]).

## 2. Observations

Near-infrared spectra were taken during 2010, using the NICS camera-spectrograph at 3.56 m Telescopio Nazionale Galileo (La Palma, Spain). Asteroids were selected according to their visibility at the corresponding scheduled observation, with no particular bias. An example of the obtained spectra can be seen in Fig. 1. Visible spectra from other databases ([6],[7]) have been used to complete our data set.

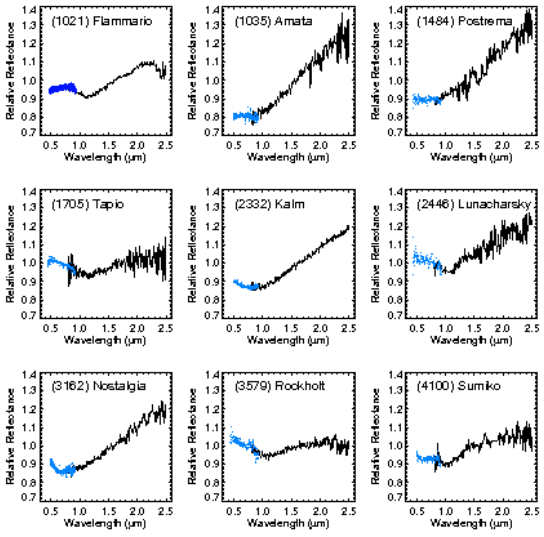


Figure 1. Near-infrared spectra of several B-type asteroids presented in this work. Visible spectra have been taken from other databases (blue).

Additional visible and near-infrared spectra of previously published B-type asteroids have been collected to enlarge our sample ([1],[8],[9],[10]). A total of 43 B-type asteroids are analyzed in this work. Fig. 2 shows the distribution of the objects in the main belt, which is uniform. Due to the particular sources of complimentary data ([1],[8]), some

concentrations of objects in the Themis and Pallas families are seen in the figure. Several near-Earth asteroids are also included in our sample.

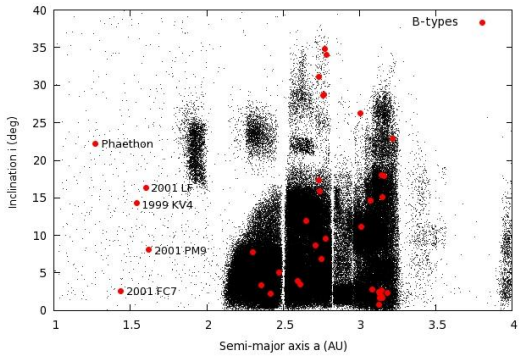


Figure 2: Inclination vs. semi-major axis of the B-type asteroids analyzed in this work. The asteroids are uniformly distributed in the main belt. Some near-Earth asteroids are also included in the sample.

## 3. Clustering and meteorite comparison

A total of 43 visible and near-infrared spectra of B-type asteroids are analyzed here. Normalizing the spectra to unity at 0.55 μm and plotting them all together, it is clear that there is a sort of continua in the near-infrared, a smooth transition between "red" and "blue" slopes (see Fig. 3).

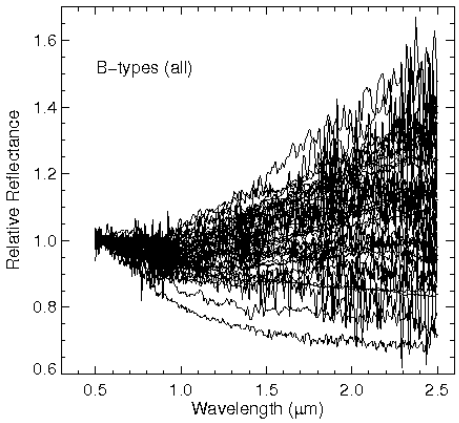


Figure3. Visible and near-infrared spectra of the complete sample of B-type asteroids analyzed in this work. A continuous transition in the near-infrared from red to blue spectral slopes is clearly seen.

To optimize compositional analysis, we have used a statistical approach to sort spectra with similar properties into distinct clusters ([11]). This procedure reduces data volumen retaining the quantitative properties of the original spectra. The resulting 6 "average spectra" or "centroids" are then compared against the entire RELAB database to search for best analogs in terms of mineralogical composition. Preliminary results show that all the centroids present good matches with carbonaceous chondrites, in particular with CM, CI and CV sub-groups.

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