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Recovery of asteroids in the Digitized First Byurakan survey

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The project

This project was started on the initiative of J. Berthier and W. Thuillot (IMCCE, Paris), and A. Sarkissian (IPSL, Paris). It aimed at discovery and study of the low-dispersion spectra (5 nm resolution spectra ranging from 340 to 690 nm) of the known solar system objects, mainly asteroids, in the DFBS fields [1]. With a limiting V magnitude closed to 18 for the fainter sources in the FBS, we roughly estimate to a few hundreds the number of spectra of asteroids that can be detectable in the 1667 plates of 4 square degrees of the DFBS.

Objectives

The spectral characterization of asteroids is important for understanding the evolution of their compositional and mineralogical properties. This knowledge is also important to study and quantify the physical properties of the interior of asteroids (e.g. composition, structure, bulk density, ...). Nowadays, the number of asteroids for which spectra have been acquired is about few thousands. Most of them have been recorded in the past 20 years during dedicated surveys (e.g. [2], [3], [4]). Even if these surveys have already measured most of the brighter asteroids which may be detectable in the DFBS, it remains useful to discover spectra in the DFBS in order to carry on the building up of the collections of spectra of asteroids in the visible wavelength. It could also offer a unique opportunity to study the time-dependent modification of the surface reflectivity of asteroids by comparing the FBS spectra (acquired between 1965 and 1980) and recent ones (post 1990).

Recovery of asteroids

The actual number of asteroids which are detectable in the DFBS depends on their magnitude and apparent velocity at the epoch of observation combined with the exposure time of the plates ranging from 15 to 90 minutes. For a given exposure time, the spectrum of a given asteroid is spread over the plate in the direction of its motion proportionally to its apparent velocity. The figure 1 shows the spectrum of the main-belt asteroid 104 Klymene extracted from the plate #126 (taken on Nov. 14, 1969). Its apparent motion of 31 arcsec per hour is clearly showed in the image by a 22 pixel width trail in the direction of its motion (materialized by the computed apparent velocity vector). However, the motion of an asteroid may be any direction, and, in particular, in the direction of the figure of the spectrum. In this case, the spreading of the spectrum overlaid the spectrum itself so that it makes the analysis more difficult.

The extraction of asteroid spectra in the DFBS plates requires to solve two main issues: the identification of the targets in the plates and the calibration of their spectra. The localization and the identification of the solar system objects in the field of views are performed using the SkyBoT web-service [5]. This Virtual Observatory (IVOA) tool makes easy to know which asteroids are located in any field of view at any epoch. Then, by looking among the known asteroids located in each plate, we are able to cross match them with the sources taking into account the known stars.

The main difficulty to analyze DFBS spectra arises with their wavelength and photometric calibrations. The FBS is composed of 16x16 cm plates covered by various photographic emulsions (mainly Kodak IIAF, IIaF, IIF and 103aF) which have been digitized. In order to calibrate each spectrum, we have to take into account the sensitivity function of the emulsion combined with the transmission function of the optics (which is important in the UV). However, as it was common

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at the time to modify the chemistry of the emulsion to improve the sensitivity of the plates to calibrate spectra, we cannot directly use the theoretical sensitivity function has it is, because it varies from plate to plate. More, alignment of the objective prism, the plate and the scanning direction is variable from plate to plate and within the same plate. To solve these issues, we have developed a dedicated workflow in the Virtual Observatory framework. All spectra are extracted from plates taking the middle and the width of the best Gaussian fitted to each horizontal line of the spectrum. The complete spectrum is corrected of inclination by linear interpolation in pixel space. Then, the spectrum of a sun-like star, closed to the target, is picked up and is compared to its reference spectrum to provide the component of the sun light and an estimation of the emulsion correction in the neighborhood of the target.

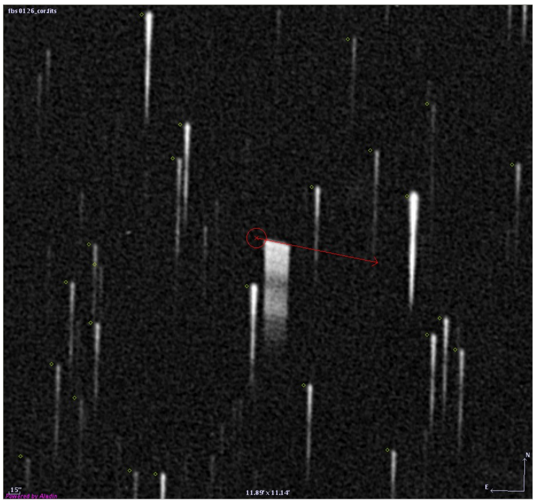

Figure 1: Snapshot of a small area (12x12 arcmin) of the plate #126, recorded on Nov. 14, 1969, showing the spectrum of 104 Klymene (Mv = 11.6). The arrow materialize its apparent motion on the celestial sphere. The green rhombs show the USNO-B1 stars identify in the FOV (mag < 17).

First results

The analysis of the DFBS has led to the recovery of 216 asteroids up to magnitude 16. The full analysis of the asteroid spectra must now be performed by means of the classical methods used to analyze planetary spectra. That will provide physical characterizations of the objects, such as the surface spectral reflectance in the visible and, therefore, an estimation of the composition of the surface of the recovered asteroids.

Acknowledgements

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