The IMCCE Virtual Observatory Solar System Portal: a tool for data mining and selection of plates to be analyzed

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Introduction

The IMCCE Virtual Observatory solar system portal (http://vo.imcce.fr/) aims to provide to the astronomical community all the knowledge and the expertise of the IMCCE which concern the dynamics and the physics of the solar system bodies. The portal offers access to an information system dedicated to solar system objects (SSO), to ephemeris computation services, and tools dedicated to data mining. All of them are fully compliant with the interoperability concept of the Virtual Observatory.

The VO solar system portal is developed by the VO team of the IMCCE, with the support of the VO Paris Data Centre of the Paris observatory, the *Centre National de la Recherche Scientifique* (CNRS) through the project ASOV-France (Action Spécifique Observatoire Virtuel), and the *Ministère de l'Education Nationale*. The VO solar system portal could be developed thanks to the efforts of the international astronomical community, through the International Virtual Observatory alliance (IVOA) which led to the construction of the Virtual Observatory, and to the support brought by the European Virtual Observatory (EURO-VO) project and the *Centre de Données astronomique de Strasbourg* (CDS).

1. Solar system object ephemerides

The Miriade project aims to provide a VO-compliant suite of services to compute positional and physical ephemerides of known solar system bodies, offering:

- Ephemerides of planets, natural satellites, asteroids and comets for any location on Earth, as well as various locations in space (HST, SPITZER, Gaia, etc.)
- Original features for the modelling of the physical apparent aspect of asteroids, taking into account their spin and shape models made available from light-curve inversion techniques [15] and/or high resolution imaging from optical telescopes and radar observations
- Radial velocity, albedo and thermal maps of some asteroids
- Different visualisation and data-format outputs for uploading, which can be directly usable into many applications. For instance, a VOTABLE providing ephemeris data, or a FITS file showing, for a given target at a given epoch, the size, the distribution of brightness, ...
- Possibility to be used for further convolution with an instrument PSF or a transfer function

- Computation of the rise, set and transit of the major solar system bodies (Sun, Moon and planets)

- computation of the visibility of SSO to prepare observing nights (ViSiON)

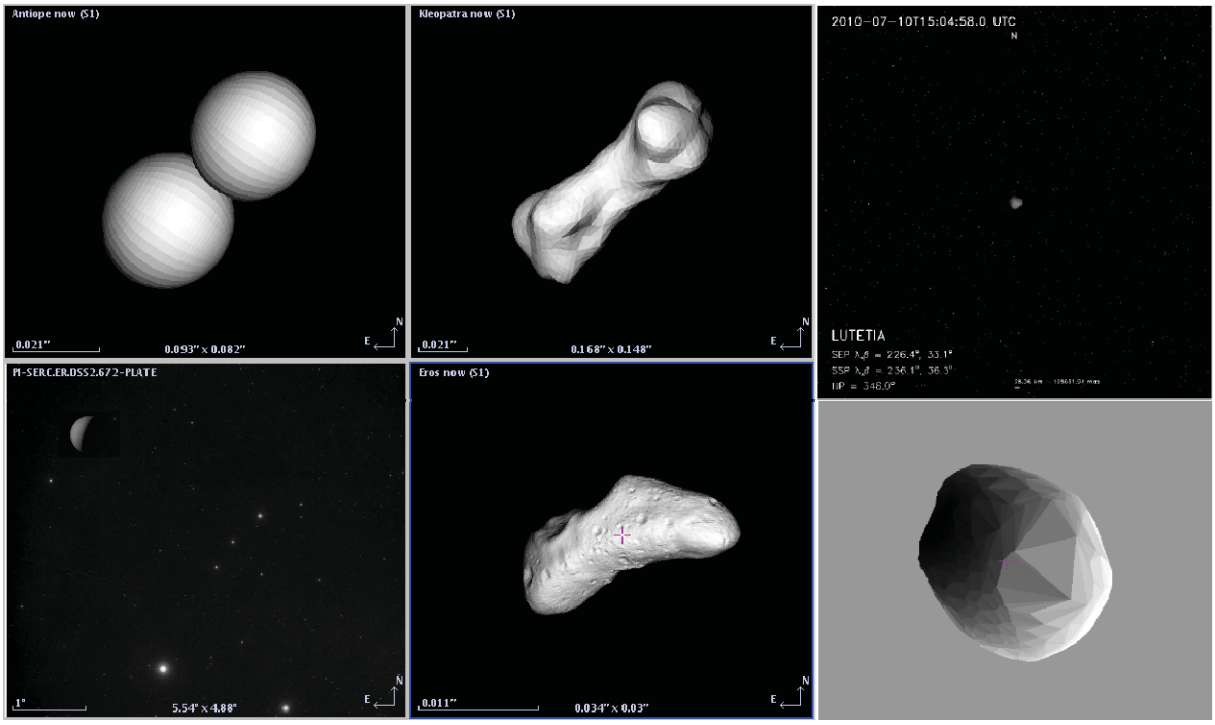


Fig. 1: Various output provided by Miriade service

2. Data mining

2.1 *SkyBoT*

The SkyBoT (Sky Body Tracker) [1] service aims to provide to astronomers a VO tool useful to seek and identify solar system objects into past and recent astronomical images. It is based on a database of pre-computed ephemerides (from 1889-11-13 to 2060-03-14) of all of the known solar system objects. SkyBoT can also be used to resolve the names of the solar system objects into their celestial coordinates at a given epoch, as well as to get their dynamical class.

2.2 *AstroId*

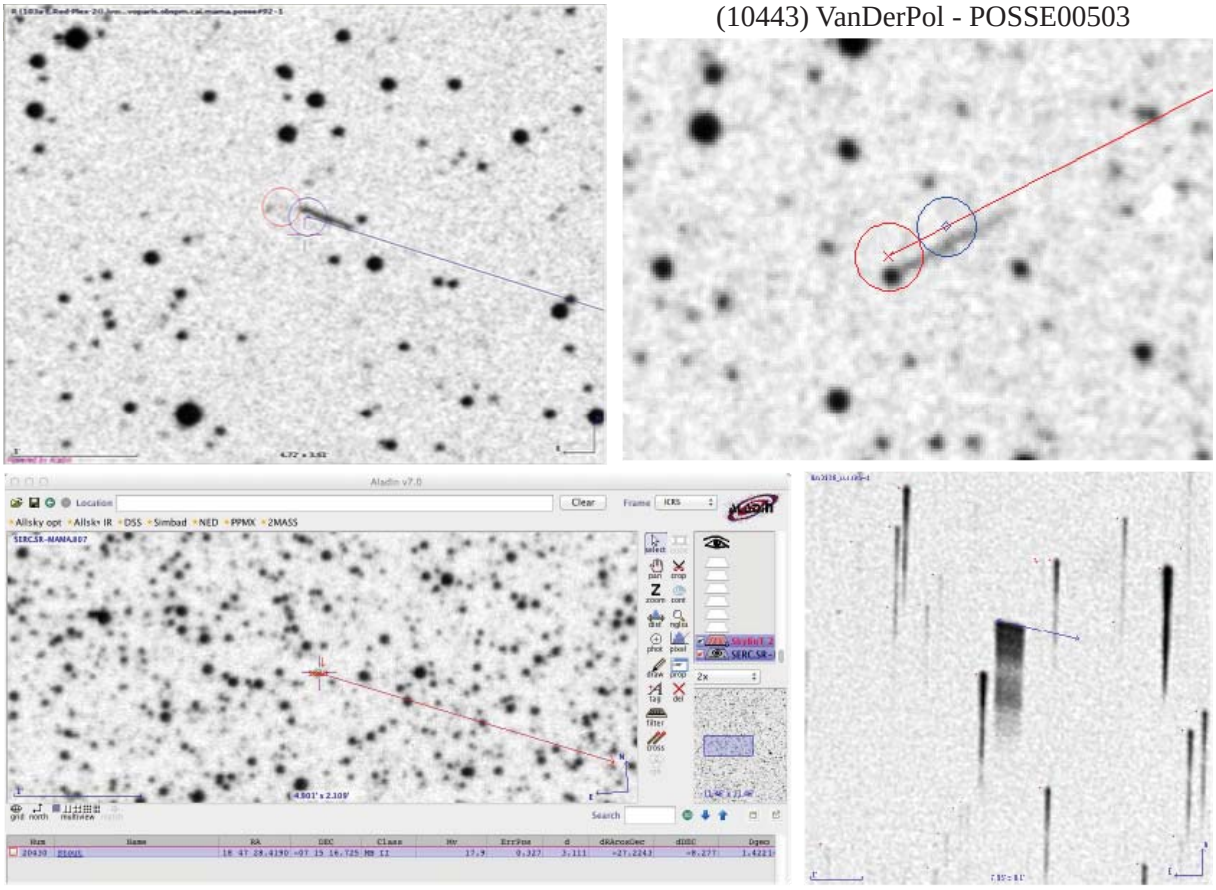
Nowadays, the huge amount of observational data which is available to the community imposes the need for fast and reliable tools so as to process all this information. In particular, the data mining of past sky surveys can provide numerous non-exploited astrometrical positions and multi-wavelength magnitudes (from visible to near infrared) of the solar system objects. Moreover this information can go back prior to the discovery of the objects, so that they are particularly useful to improve our knowledge of their orbits and, especially for Near Earth Objects (NEO), to compute more accurately their ephemeris in the future.

The AstroId service aims to provide a VO-compliant tool dedicated to this work. It has been designed to perform an automatic cross-matching between astronomical sources and known celestial objects

(stars and SSO), in order to identify known SSO into any astronomical archives. As a first application, we have analysed the near-infrared sky survey DENIS, and, among the 5206 strips of the survey (each strip being composed of 90 images), we have found approximately 20 800 correlated observations of ~15 600 SSO of which 313 observations concern 230 NEOs. We have also found 7720 unclassified celestial objects of which a part is certainly unknown SSO at that day. In collaboration with the Byurakan observatory, we have analysed the spectroscopic *First Byurakan Survey*, and identified about 300 asteroid spectra among the $20x10^6$ spectra which have been extracted from the 2180 plates of the survey. The next step will be the data mining of sky surveys such as the French "*Carte du Ciel*", EROS (1, 2), ESO-R, SRCJ, POSSE, …

(3057) Malaren - POSSE0092

(10443) VanDerPol - POSSE00503



(20430) Stout - EROS-2 (2001-06-20)

(104) Klymene's - DFBS

Fig. 2: Identification of Sso into sky surveys by AstroId service

References

[1] Berthier J., Vachier F., Thuillot W., Fernique P., Ochsenbein F., Genova F., Lainey V., Arlot J.-E. 2006.SkyBoT, a new VO service to identify Solar System objects, *Astronomical Data Analysis Software and Systems* XV, 351, 367.