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Miriade: A Service for Solar Sytem Ojects Ephemerides in the VO Framework.

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Abstract

Ephemerides of solar system bodies are needed for many applications such as operation of the telescopes, prediction of instruments performance, planing of observation campaigns, reduction of astrometric, photometric, or spectrometric data, analysis of space probe images, etc. Dynamical and physical studies of the small bodies of the solar system based on stellar occultation, astrometry, photometry, radiometry and high angular resolution observations also show the need of having good ephemerides over mid-term time scales. In this paper we give a presentation of Miriade, the new version of the IMCCE ephemeris service on the web. It is a major upgrade from the previous services available at IMCCE providing positional and physical ephemerides of planets and small bodies (asteroids, comets, satellites) of the solar system as well as some physical data. Miriade is part of the more general IMCCE-VO solar system portal[1] in the Virtual Observatory (VO) framework, making use of a name resolver for the solar system bodies, and providing several functions:

- SSODNET, Solar System Object Database NETwork node, an information system connecting various database trhough a search engine;

- SKYBOT, the Sky Body Tracker for object identification in astronomical images, that has been implemented in the Aladin software (CDS) for several years [1]. Skybot provides the position and apparent velocity of any known object present in a given field of view at a given time;

- AstroId, a data mining tool. It relies on the skybot tool which has been used in data-mining of solar system objects in the HST-ESO archive. Similarly data-mining of the DENIS survey has been performed with the use of the sky body-tracker.

- VO-Noe an orbit determination and improvement node;

- Sso-TEP, prediction of transient events and phenomena, combined with an VOevent provider accessible for instance to robotic telescopes;

- and last, Miriade, the service for physical and positional ephemerides that we detail here.

Miriade provides VO-compliant web services to compute ephemerides of known solar system bodies. Theses ephemerides are either positional or physical from various location (topographic, geocentric, from space probes or any location in the solar system). Miriade extensively uses the webservice protocol and XML language; it can hence—through an internet connexion—either include and combine in real time remote data-bases, or inversely it can be directly called in a program code. Such interoperability has already been implemented at the CDS through the VizieR and Aladin systems [2]. In its generalities and usual webinerface Miriade is similar to the most used JPL Horizon system [3] and previous ephemeris generator at IMCCE. However with the present upgrade it shows some fundamental technical aspects allowing different and more extensive use through generic web-service and Virtual Observatory protocol.

Various modes of computation and dynamical models can be combined easily through a web-service protocol. Positional ephemerides of all satellites are now available together with modern planetary ephemeris (DE, INPOP) and ephemerides for known asteroids and comets (by numerical integration taking into account planetary perturbations, relativistic and non-gravitational effects). In the case of the ephemerides for the physical observations, one can produce—starting from a given 3D shape-model, spin state and light-scattering—the orientation, apparent size, apparent shape, and brightness distribution as seen from any location (Fig. 1). The shape models and spin state are extracted from specific database obtained from radar observations, space probes imaging, and mostly from lightcurve inversion and high-resolution imaging. Such models are available for a few asteroids, comets and planetary satellites. Different visualizations and data-

[1] URL http://vo.imcce.fr/webservices

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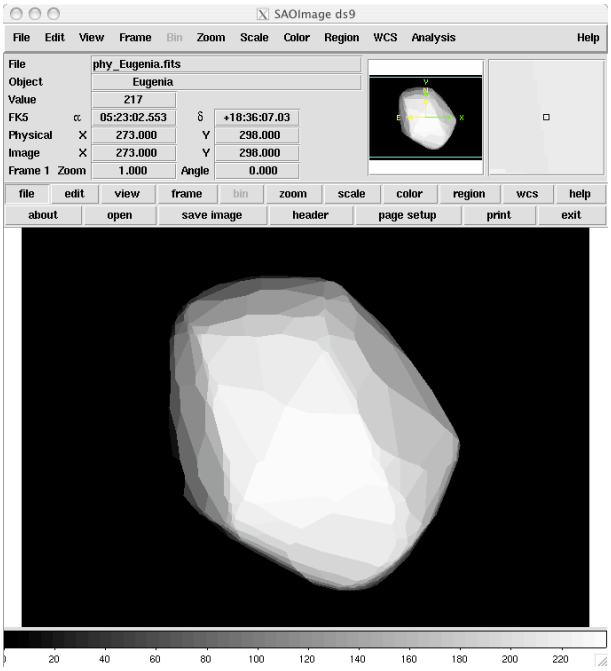

Figure 1: Example of a FITS image generated by Miriade system showing the orientation, apparent shape and brightness distribution of the asteroid 45 Eugenia. The 3D-model is extracted from he DAMIT database (J. Durech & V. Sidorin Charles univ., Prague).

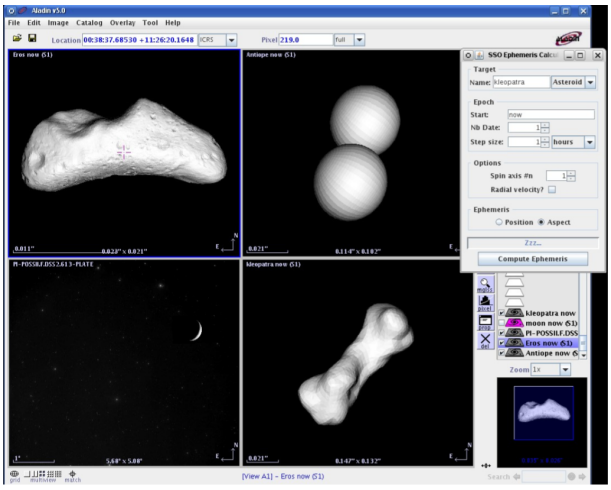

Figure 2: Solar System Object ephemeris calculator plugin in the Aladin software from CDS.

format outputs are available either from uploading or directly through a web-service. For instance one can generate a file in FITS format with a header containing all the ephemeris data and a table to be used for further use (e.g. convolution with an instrument response or transfer function [4]). The Miriade tool is implemented at the CDS Aladin sky atlas system through the SSO-ephemeris calculator plugin (Fig. 2). Albedo and thermal maps will be included in future releases of the physical ephemeris. A general synthetic data base including several thousands of objects to be used by the Gaia data reduction consortium is under development.

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