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The Auroral Planetary Imaging and Spectroscopy (APIS) service

L. Lamy [a,*], R. Prangé [a], F. Henry [a], P. Le Sidaner [b]

[a] *5 place Jules Janssen, 92190 Meudon, France*

[b] *DIO-VO, UMS2201 CNRS, Observatoire de Paris, 61 avenue de l'Observatoire, 75014, Paris, France*

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ABSTRACT

The Auroral Planetary Imaging and Spectroscopy (APIS) service, accessible online, provides an open and interactive access to processed auroral observations of the outer planets and their satellites. Such observations are of interest for a wide community at the interface between planetology, magnetospheric and heliospheric physics. APIS consists of (i) a high level database, built from planetary auroral observations acquired by the Hubble Space Telescope (HST) since 1997 with its mostly used Far-Ultraviolet spectro-imagers, (ii) a dedicated search interface aimed at browsing efficiently this database through relevant conditional search criteria and (iii) the ability to interactively work with the data online through plotting tools developed by the Virtual Observatory (VO) community, such as Aladin and Specview. This service is VO compliant and can therefore also been queried by external search tools of the VO community. The diversity of available data and the capability to sort them out by relevant physical criteria shall in particular facilitate statistical studies, on long-term scales and/or multi-instrumental multi-spectral combined analysis.
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1. Introduction

Ultraviolet (UV) planetary astronomy provides a wealth of information on planetary environments of the solar system and beyond (Gomez de Castro et al., 2014, and refs therein) and benefits a good angular resolution. Planets, moons and rings primarily reflect the (time variable) solar continuum (Cessateur et al., 2011) with various albedos, depending on their composition and dynamics. The UV domain is also adapted to measure intrinsic atmospheric emissions such as airglow and aurorae, which are produced by electronic transitions of neutral species prevailing in the upper atmosphere of giant planets (as H and H_2) and their satellites (as O) that are collisionally excited by precipitating charged particles. Airglow is a weak radiation emitted over the whole atmospheric disk and powered by solar fluorescence and photoelectron excitation (Barthélemy et al., 2014, and refs therein). In contrast, aurorae are bright localized emissions radiated from the auroral regions of magnetized planets (or of conductive moons interacting with them) by energetic charged particles accelerated farther in the magnetosphere (Badman et al., 2014, and refs therein). Auroral observations, on which we focus hereafter, thus provide direct constraints on the electrodynamic interaction between planetary atmospheres, magnetospheres, moons and the solar wind as well as on the underlying plasma processes at work (particle acceleration, energy and momentum transfer). Auroral spectro-imaging in the UV provide key observables, such as the spatial topology and dynamics of the active magnetic field lines, the radiated and precipitated power, and even the energy of precipitating electrons (Gustin et al., 2013; Tao et al., 2014).

Among space-based UV observatories, the Hubble Space Telescope (HST) intensively observed the aurorae of outer planetary systems (Jupiter, Saturn, Uranus) in the Far-UV (FUV, 116 to 200 nm) from 1993 up to now, providing thousands of images and spectra, often in the frame of combined observations with spatial probes dedicated to planetary exploration such as Galileo (in orbit around Jupiter over 1995–2003), Cassini (flyby of Jupiter in 2000, in orbit around Saturn since 2004) and New Horizons (flyby of Jupiter in 2007) or with Earth-based observatories observing in the radio, IR and X-rays domains. Fig. 1 displays examples of HST-FUV observations of giant planetary systems. These observations now form a rich database, of interest for a wide community interested in planetary magnetospheres, planetology and heliospheric physics in the outer solar system. However, their use by non-specialists remains limited by their complexity, the lack of high level data and associated Figures, and the difficulty to access them.

The Auroral Planetary Imaging and Spectroscopy (APIS) service, accessible at http://apis.obspm.fr, aims at providing an open and easy access to a high-level auroral database, built from public HST observations processed in convenient formats, and compliant with

* Corresponding author.
E-mail address: laurent.lamy@obspm.fr (L. Lamy).

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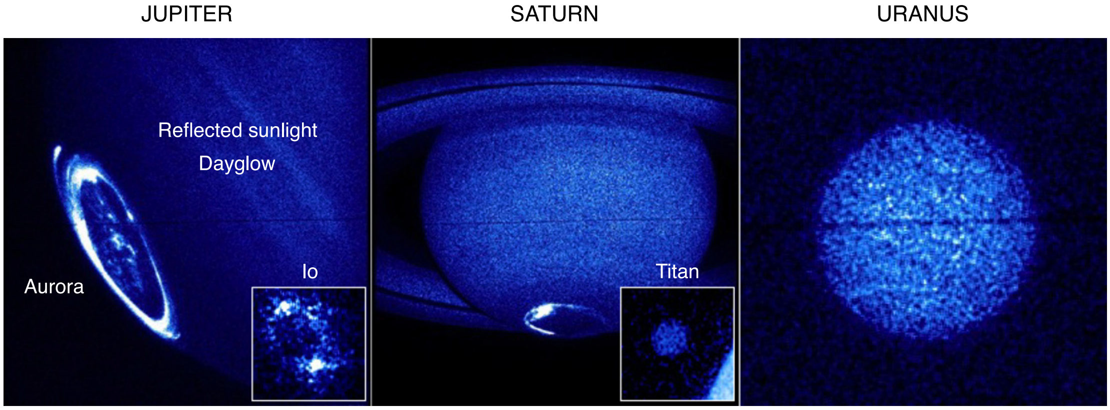

Fig. 1. Images of outer planets and satellites obtained by the ESA/NASA Hubble Space Telescope in the Far-UV, available through the APIS database.

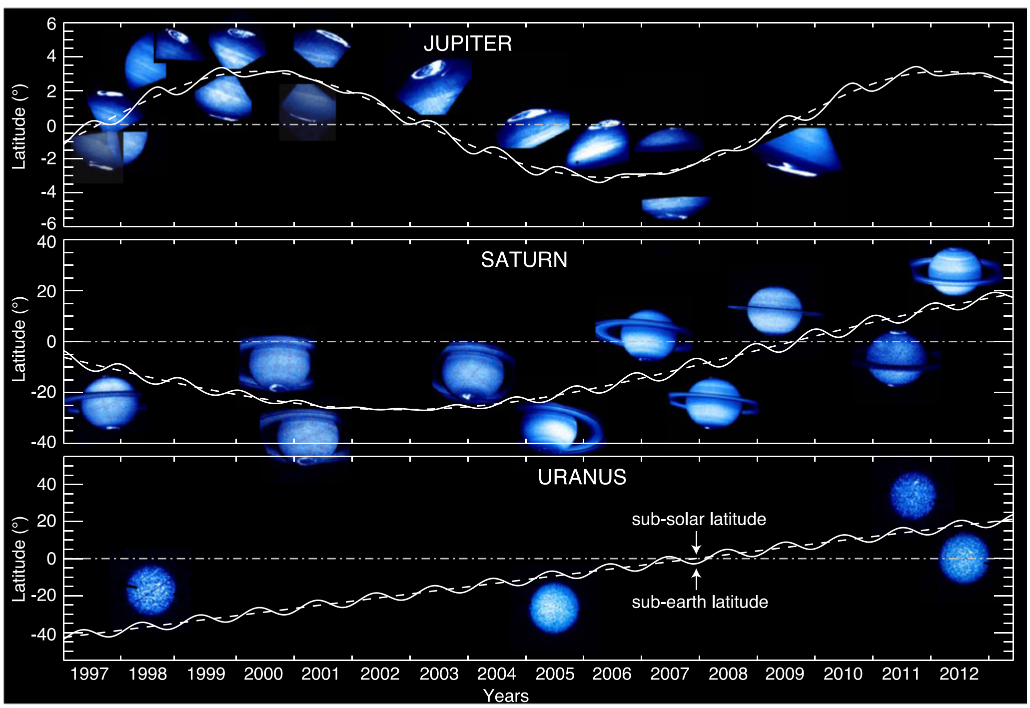

Fig. 2. Sub-Earth (solid line) and Sub-solar (dashed line) latitude of Jupiter, Saturn and Uranus as a function of time, together with combined HST images indicating the main STIS/ACS observing campaigns since 1997.

virtual observatory (VO) facilities. It thus contributes to current efforts of the VO planetology community to develop standardized databases and tools to access them. It has been open to the community in July 2013 (Lamy et al., 2013a). Fortuitously, the bull APIS is also the ancient Egyptian god of (data) fertilization, wearing an (active) solar disk between its horns.

2. A high level database

APIS primarily relies on a high level database, archived at Virtual Observatory-Paris Data Centre (VO-PDC) and based on HST FUV auroral observations of the outer planets and their moons acquired since 1997. For convenience, we restricted to the mostly used instruments, namely the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS), using the FUV and the Solar Blind Chanel (SBC) Multi-Anode Microchannel Array (MAMA) detectors, respectively. We refer the interested reader to the STIS and ACS handbooks provided by the Space Telescope Science Institute (STScI) for further details. To date, the considered observations consist of about 6000 individual images and spectra, issued from 37 observational campaigns of the Jupiter, Saturn and Uranus systems distributed as illustrated in Fig. 2, and obtained with very diverse instrumental configurations (filters for imaging, combination of slit and gratings for spectroscopy). For each of these individual observations, APIS provides a set of value-added data levels briefly described below, each available in work and graphical formats such as *fits* files (Pence et al., 2010) and *jpeg, pdf* plots.

2.1. Imaging

Images are provided under three levels of data: original images as calibrated by STScI (level 1), spatially re-oriented and fitted images provided with pixel planetocentric coordinates (level 2) and background-subtracted cylindrical/polar projections transposed into physical units (level 3). At the bottom of Fig. 3, the row labeled “Images” (in blue) illustrates these data levels with quick looks, below which are provided various data formats.

Level 1. Original images – or level 1 images – originate from public data delivered by STScI through the Mikulski Archive

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