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The World Space Observatory -Ultraviolet (WSO-UV) Space Telescope; Status Update in 2013

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Abstract

This is a short primer and a brief update on the status of the World Space Observatory-Ultraviolet (WSO-UV) project dated in May 2013. WSO-UV is a 170m primary space telescope equipped for ultraviolet imaging and spectroscopy that will be operational in 2017 hosting an open science program for the world-wide scientific community.

Keywords: astronomical instrumentation - space astronomy - ultraviolet astronomy.

1 Introduction

The ultraviolet (UV) range is fundamental for astrophysical investigations, since the resonance transitions of the most abundant species in the Universe occur at these wavelengths/energies. The radiation cut-off at wavelengths shorter than 2800 Å by the Earth's atmosphere makes UV astronomy only accessible from space. Thus UV astronomy began with Space exploration. After the Copernicus mission, the International Ultraviolet Explorer (IUE) was launched in 1978, becoming the first UV space observatory operated in real time; the IUE allowed to carry out spectroscopic observations from 1150Å to 3200Å. Later on, the Far Ultraviolet Spectroscopic Explorer (FUSE) mission (1999-2007) opened the 900Å -1000Å spectral range for spectroscopic studies. The Galaxy Evolution EXplorer (GALEX, 2003-2011) has mapped, for the first time, the UV sky. As today, the Hubble Space Telescope (HST) is the only operational mission in the UV range. HST is expected to last for a few more years. All these missions have amply demonstrated the feasibility and relevance of UV studies (see Gómez de Castro et al. 2006, Gómez de Castro & Brosch 2009, for detailed compilations).

The World Space Observatory-Ultraviolet (WSO-UV) is an international space mission born as a response to the growing demand for UV facilities by the astronomical community. In the horizon of the next decade, the WSO-UV will be the only two-meters class mission in the post-HST epoch which will guarantee access to UV wavelenghts. The project is managed by an international consortium led by the federal Space Agency ROSCOSMOS (Russia).

In this article, we briefly describe the WSO-UV project, its general objectives and its main features. Special emphasis is made on the ground segment and the instrument ISSIS, the contributions of Spain to the project.

Figure 1: The WSO-UV Space Observatory.

2 The WSO-UV Scientific Objectives

The WSO-UV is a multipurpose observatory on a geosynchronous orbit, which will provide data of large importance to investigate several open problems in astrophysics. The science drivers of the project are:

- The study of the diffuse baryonic content in the Universe and its chemical evolution – the main topics will be the investigation of baryonic content in warm and hot IGM, of damped Lyman-α

systems, the role of starburts and the formation of galaxies.

- The study of the formation and evolution of the Milky Way – the UV plays a particularly important role in the determination of energy inputs of the gas interacting with stars, and in the investigation of magnetic fields on star formation. The Milky Way history could be tracked through observations complementary to those obtained by the GAIA mission.

- The physics of accretion and outflows: the astronomical engines – This cathegory includes stars, black holes, interacting binaries, pre-main sequence stars an, in general, all those objects where accretion plays an important role in the evolution of the system. The efficiency and time scales of the phenomena will be studied, together with the role of the radiation pressure and the disk instabilities.

- The investigation of the (extra)solar planetary atmospheres and astrochemistry in presence of strong UV radiation fields – the properties of the atmospheres of T Tauri stars to study the environment where protoplanets grow.

(see also Gómez de Castro et al. 2009)

3 The WSO-UV Mission and Instrumentation

The WSO-UV telescope has an F/10 Ritchey-Chretien mounting with a primary diameter of 170 cm. WSO-UV has been thought as an observatory-type mission henceforth carrying instrumentation for UV imaging and spectroscopy (Shustov et al. 2009, 2011).

The WSO-UV imaging and slitless spectroscopy instrument (ISSIS) is a multipurpose instrument with a mode selector wheel that permits to carry out imaging and slitless spectroscopy in the 1150-3200 Å spectral range. The instrument is equipped with two MCP detectors, with CsI and CsTe photocathods for FUV and NUV observations, respectively.

The WSO-UV spectrographs (WUVS) consists of a set of three instruments:

- The far UV high resolution spectrograph (VUVES) that will permit to carry out echelle spectroscopy with resolution R$\sim$50,000 in the 1150-1760 Å range. It will be equipped with a photon-counting, Micro Channel Plate (MCP) detector

- The near UV high resolution spectrograph (UVES) to carry out echelle spectroscopy with resolution R$\sim$55,000 in the 1740-3050 Å range. It will be equipped with a CCD detector to observe in the near UV.

- The Long Slit Spectrograph (LSS) that will provide low resolution (R$\sim$ 1000), long slit spectroscopy in the 11500-3050 Å range. The spatial resolution will be 1 arcsec also, the width of the slit is 0.5 arcsec. The detector is a CCD cooled to -100^o C to be sensitive to the Far UV.

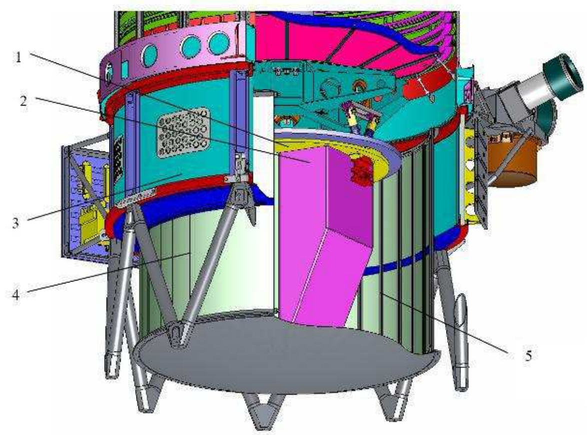

Figure 2: The instruments compartment in WSO-UV.The numbered sections correspond to: [1] optical bench with ISSIS and WUVS mounted, [2] spectrographs, [3] cylinder inset of the instruments compartment, [4] protective cover of the instruments compartment and [5] heat pipes.

(see also, Sachkov 2010)

Prior to final tests, after the end of the construction phase, WSO-UV instrumentation is expected to provide sensitivities similar to those of the HST instrumentation. The factor of 2 difference in the collecting surface between HST and WSO-UV is compensated by the, much more efficient, high Earth orbit of the WSO-UV, a geosynchronous orbit with inclination 51^o. This will also allow to carry out efficiently monitoring programs. Moreover, modern "state of the art" CCD detectors will be used in the spectrographs.

WSO-UV expected launch date is 2016 and will be operational for five years with a possible extension to five years more. The space telescope is planned to be operated from two sites at Madrid (UCM) and Moscow (INASAN) that will also host also the Science and Mission Archives. The ground segment is being designed under a shared operations scheme.

3.1 ISSIS design and expected performance

The Imaging and Slitless Spectroscopy Instrument (ISSIS) will be a key part of the WSO-UV instrumentation. ISSIS is the first UV imager to be flown to high Earth orbit, above the Earth geocorona. Hence the UV background will be dominated by the zodiacal contribution and the diffuse galactic background due to dust-scattered starlight (Murthy et al. 2010). The instrument has been designed to make full benefit of the heritage left by the GALactic Evolution eXplorer (GALEX) mission. GALEX has surveyed about 80% of the sky at UV wavelengths, providing for the first time a nearly complete view of the UV Universe (Martin et al. 2003, Bianchi et al. 2011). However, GALEX spatial resolution was ~ 4.2 arcsec and had very moderate spectroscopic capabilities. ISSIS resolution will be ≤ 0.1 arcsec. The Fine Guiding System of the WSO-UV telescope will guarantee a high pointing stability (better than 0.1 arcsec at 3σ). Moreover, ISSIS will be equipped with gratings for slitless spectroscopy with resolution 500, in the full 1150-3200 spectral range. In imaging mode, ISSIS effective area is about 10 times that of the GALEX imagers.

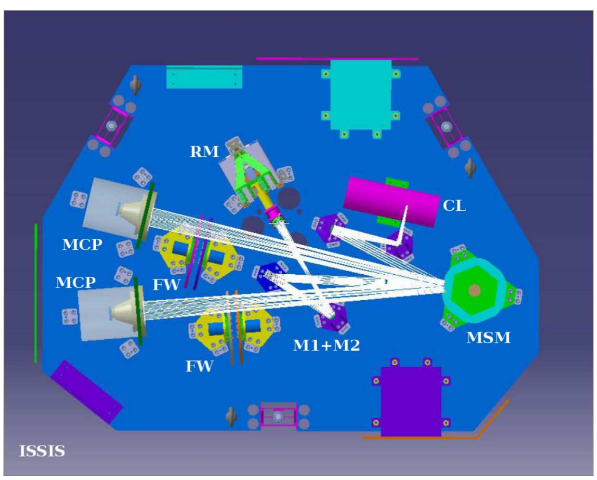

Figure 3: The layout of the Imaging and Slitless Spectroscopy Instrument (ISSIS). The acronyms mark the location of: detectors (MCP), filter wheels (FW), pick-up mirror mechanism (RM), calibration lamp (CL), mode selector mechanism (MSM) and the mirrors M1 and M2.

ISSIS is designed to be an instrument for analysis of weak UV point sources or clumpy extended sources, especially those with well defined geometry. UV imaging instruments have been often equipped with prisms or very low dispersion grisms. The rapid decay of the resolution of prisms such as the available in the Solar Blind Channel (SBC) of the Advanced Camera System (ACS) makes very difficult its use to map extended line emission at wavelengths above some 1350 Å. As the transmittance of narrow band filters in the far UV is $\leq 3\%$, integral-field low resolution spectroscopy is the main mean to map nebular emission. ISSIS gratings will make feasible to use the powerful UV diagnostic tools to determine the location of dusty blobs and measure electron densities and temperatures.

The instrument is located below the primary mirror and above the optical bench. This location imposes additional constraints to the design, in terms of weight and size: the maximum weight on the optical bench is 61.5 kg, and the full instrument has to be fit within a flat cylinder of height 17 cm. ISSIS is fed by the central part of the beam but a pick-up mirror is required to fold the beam from the telescope adding one reflection. The final design is a compromise between the scientific requirements and the telescope/platform requirements. Figure 3 shows the layout of the instrument.

4 WSO-UV Science Programs

The WSO-UV will run three major science programs (see Malkov et al. 2011 for details):

- *The core program* includes the key scientific programs that will carry over the scientific objectives of the mission. The core program will be run for the first two years of the mission by the consortium building and operating WSO-UV.
- *National programs:* each country or funding body contributing to the project is entitled to receive a fraction of the observing time proportional to its contribution. After the third year of the project, 60% of the observing time will be awarded to these programs. National calls are expected to be issued for the national programs though they will be synchronized with the general project calls. Guaranteed time for the instruments teams should be included in the national contributions.
- *Open Program* to the world wide scientific community. This program will handle a 40% of the observing time after the 3rd year of the mission.

Targets of opportunity observations will be managed within these programs.

5 WSO-UV Ground Segment (GS)

The WSO-UV GS is comprised of all the infrastructure and facilities involved in the preparation and execution of the WSO-UV mission operations, which typically encompass real-time monitoring and control of the spacecraft, telescope and instruments as well as reception, processing and storage of the scientific data. In principle, there will be two complete GS systems: the Russian one will be located in Moscow (Lavochkin Association and Institute of Astronomy of the RAS), and the Spanish one will be sited at Madrid. The satellite operations will be shared between both Ground Control Centers, transferring the mission control from one center to the other on a regular basis (Lozano et al 2011).

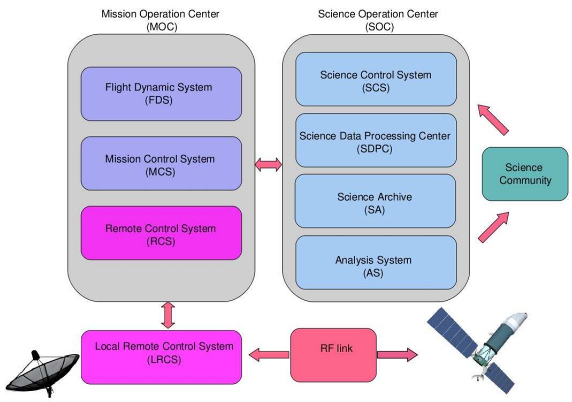

Figure 4: Basic layout of WSO-UV ground segment.

The science operations system and a fraction of the mission operations system are part of the Spanish contribution to the WSO-UV. The Remote Proposal System (RPS), the Science Data Processing System (SDPS), the Science Archive (SA) and the Scheduling systems are defined by the international science team composed by Spanish and Russian Science Support Teams based at the Universidad Complutense de Madrid (UCM) and Russian Science Institute of Astronomy of the Russian Academy of Science (INASAN). The Science Support Team (ST) is part of the man power of the GS, and is responsible of laying the foundation of and supervising all the operations related to the mission primary users: the scientists. At mission level, the ST constitutes the core of the future WSO-UV international observatory. A sumary of the high level definition documents, approved at mission level, for the development of the main science systems for WSO-UV GS can be found in Gómez de Castro et al. 2011.

6 Conclusions

WSO-UV is an international observatory that will grant access to the UV range in the post-HST era. At the time these proceedings are being written, the project is evolving into the construction phase.

Acknowledgement

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DISCUSSION

JAMES BEALL: Any idea of a possible launch date?. It's a beautiful instrument.

ANA I. GOMEZ DE CASTRO: The foreseen launch date is end of 2016.

NINO PANAGIA: I believe this is a very important project. I'm wondering what is its expected lifetime.

ANA I. GOMEZ DE CASTRO: The mission lifetime is 5 years plus 5 additional years after review.