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The Son of X-Shooter (SOXS) and the Extrasolar Planets

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Abstract

Son Of X-Shooter (SOXS) will be a new instrument designed to be mounted at the Nasmyth–A focus of the ESO 3.5 m New Technology Telescope in La Silla site (Chile). SOXS is composed of two high-efficiency spectrographs with a resolution slit product 4500, working in the visible (350 – 850 nm) and NIR (800 – 2000 nm) range respectively, and a light imager in the visible (the acquisition camera usable also for scientific purposes). The science case is very broad, it ranges from moving minor bodies in the solar system, extrasolar planets, bursting young stellar objects, cataclysmic variables and X-ray binary transients in our Galaxy, supernovae and tidal disruption events in the local Universe, up to gamma-ray bursts in the very distant and young Universe, basically encompassing all distance scales and astronomy branches. Here we present what we would like to do in the extrasolar planets field. The first light of the instrument is foreseen for the first half of 2021.

1. Introduction

In 2015 ESO selected SOXS out of 19 proposals in response to the "Call for Scientific Projects for the NTT on the La Silla Observatory", which had been issued in February 2014. SOXS has a key role in the new ESO strategy for the La Silla Observatory described in the ESO long term plan, that envisages the dedication of the two telescopes operated by ESO in La Silla to specific topics. They are the study of the transient sky with SOXS at the NTT and the radial velocity studies for exoplanets with HARPS and the new instrument NIRPS at the 3.6m telescope. As a sort of pathfinder to the SOXS main science, a large fraction of the NTT observing time over the past few years has been dedicated to a public spectroscopic survey (the Public ESO Spectroscopic Survey of Transient Objects – PESSTO) with 150 nights per year and a Large Programme (ePESSTO) with 200 nights over two years. SOXS will simultaneously cover the electromagnetic spectrum from 0.35 to 2.0μm using two arms (UV–VIS and NIR) with a product slit-resolution of ~ 4500. The throughput will enable to reach a S/N~ 10 in a 1-hour exposure of an R$= 20$ mag point source.

SOXS is supposed to start the operations in 2021. The SOXS consortium is in charge of the realization of the instrument, with duties extending also over the next operation phase, within the framework of an agreement with ESO. The consortium is supposed to provide the user support through a helpdesk. In return of the efforts and investments, the SOXS consortium will be remunerated with 900 NTT nights over 5 years. The ESO community will access the rest of the NTT observing time. The consortium will be granted a proprietary period for their data. ESO will provide telescope operators and day-time maintenance and support on site. The SOXS consortium structure has evolved since the proposal, including new partners beside the PI Institute Istituto Nazionale di AstroFisica (INAF). They are: Department of Particle Physics and Astrophysics, Weizmann Institute of Science (Israel); University Andres Bello and Millennium Institute for Astrophysics (Chile); FINCA - Finnish Centre for Astronomy with ESO & Turku University (Finland); Queen's University Belfast (Ireland); Tel Aviv University (Israel); Niels Bohr University (Denmark).

2. SOXS, the instrument

SOXS will simultaneously cover the electromagnetic spectrum from 0.35 to 2.0 μm using two arms (UV–VIS and NIR) with a product slit–resolution of ~ 4500. The throughput should enable to reach a S/N~ 10 in a 1–hour exposure of an R=20 mag point source. SOXS will be mounted at the Nasmyth focus of NTT replacing SOFI. The whole system (see Figure **??**) has three scientific arms: the UV–VIS spectrograph, the NIR Spectrograph and the acquisition camera. The three main arms, the calibration box and the NTT are connected together by the Common Path (CP).

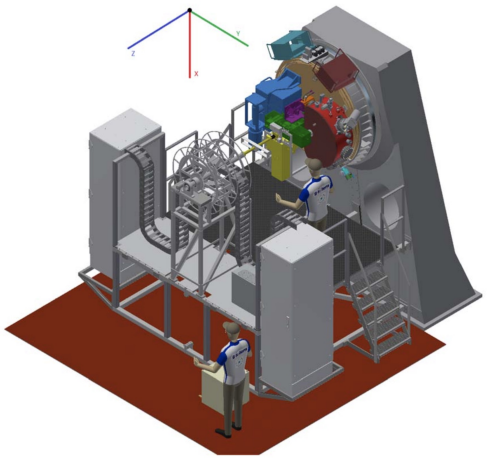

Figure 1: General SOXS view with platform and the derotator. The reference system shown is the global one.

3. Exoplanets with SOXS

In the following some example of the Exoplanets science case to be performed during GTO time.

3.1 Characterization of low-mass objects with SOXS

Gaia DR2 provided a large number of previously unknown ultra-cool objects (13000 objects with (expected) spectral type later than M7 and $>$ 1000 L type objects). Spectroscopic confirmation and more detailed characterization is needed for most of the objects, that will be too faint for Gaia on-board spectroscopy. SOXS is an ideal instrument for this task (spectral resolution, spectral coverage). Subclasses of objects of special interest can be identified, as, e.g. very young objects (potentially accreting), metal poor objects (selected from kinematics), wide companions to stars (exploiting the possibility of reliable age and metallicity determination for the primaries in order to obtain suitable benchmarks for model calibration). There is a clear synergy with program aimed at the study of the atmospheres of transiting planets, as the temperatures of objects are similar but the transiting planets are heavily irradiated while the proposed sample if formed by isolated objects. Additional targets will be provided by Gaia DR3.

3.2 Monitoring the variability of substellar objects with SOXS

Variability monitoring is of special interest for substellar objects, as it allows to study the inhomogeneities of clouds coverage and associated timescales of variations. Objects at L-T transition are especially promising. In most cases, observations are performed in photometry but medium-resolution spectroscopy as provided by SOXS will allow to study how the depth of individual bands evolved with time, providing more sensitive diagnostics. At very young ages, monitoring of spectral features sensitive to accretion will also allow to study monitor the accretion variability.

3.3 Characterization of ARIEL targets

ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey) was conceived to observe a large number (1000) of transiting planets for statistical understanding, including gas giants, Neptunes, super-Earths and Earth-size planets around a range of host star types using transit spectroscopy in the 1.25-7.8 μm spectral range and multiple narrow-band photometry in the optical. ARIEL (the launch is foreseen in 2026) will focus on warm and hot planets to take advantage of their well-mixed atmospheres. We would like to use SOXS and its large spectral band to observe ARIEL targets defined in the group of transiting planets around host stars with magnitude ranging in the 10 -13 magnitude to study the star activities at different timescales. This characterization is necessary because ARIEL will observe planetary atmospheres in the transmission spectroscopy that is a combined light technique. So, depending of the transiting planet we can have different number of transit to combine to obtain the right SNR for atmospheric studies, and it is necessary to know if the star modify its irradiation due to activity in this lapse of time.