THE UV IMAGER FOR THE ISRAELI SCIENTIFIC SATELLITE

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Abstract. Israel will orbit a satellite dedicated to scientific research. One of the two experiments studied for deployment on this platform is a three-channel imager in the ultraviolet proposed by Tel Aviv University and designed jointly by staff of the Wise Observatory and of El-Op (Electro-Optical Industries, Ltd.). The design provides very significant scientific returns in a small payload and for a moderate cost.

1. Rationale

Israel orbited two technology demonstrator satellites, in September 1988 and in April 1990. In preparation for its entry in the "space nations" club, the Israeli Space Agency (ISA) called for proposals of instruments to be orbited on a dedicated scientific satellite platform (the National Scientific Satellite-NSS). One of the two proposals selected for Phase A study is the UV imager payload (TAUVEX).

The constraints of the scientific payload imposed by ISA are mass less than 20 kg, power consumption less than 25 W and size to fit inside a cylindrical envelope of 50 cm diameter and 150 cm length. The launch constraints are similar to those of the Scout and the design lifetime is two years.

The UV imager mission seeks to exploit the dark skies in the UV region between Lyman α and the atmospheric cutoff with the constraint of a small sized payload. We proposed an imaging experiment of reasonably wide field and imaging quality, that can be accomodated in the payload envelope.

Any new mission competes with the Hubble Space Telescope (HST) and with the UIT on the ASTRO platform. The advantage of TAUVEX relative to the HST will be in the size of the imaged field, because the large collecting area and superb imaging qualities of HST are unique. The advantages relative to UIT will be in the duration of the mission, *i.e.* in the portion of the sky imaged by the payload, and possibly in the dynamic range of the experiment.

2. Design

2.1. Optics

The size constraint implies that at most a single telescope of about 40 cm aperture could be accomodated. An imaging experiment to provide interesting science must do so in a number of spectral bands. This is normally done with a filter-changing mechanism. We felt that, in the interest of reliability, we should design away from moving parts, possibly at the expense of some efficiency.

The baseline design is of three 20 cm diameter bore-sighted Ritchey-Cretien telescopes mounted on the same bezel. The telescopes have an effective f/number of 5 and the image quality is $5''$ over a $1.7°$ diameter field. This is achieved with a field

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corrector composed of two doublet groups with almost zero power. The corrector lenses also focus the optics on-orbit, should this be necessary. The physical length of each telescope is about 36 cm. The obscuration by the secondary mirror and the baffles is ~50% of the area presented to the sky.

The entire mechanical construction is of graphite-epoxy, with mirrors made of lightened Zerodur and lenses of LiF or CaF_2. A number of light shields are designed into the structure. They reduce the amount of scattered light as well as decouple the optics and structure from the cooling load of space. Thus only 11.5 W are required to keep the telescopes at +20°C.

2.2. Detectors

We requested for TAUVEX a space-qualified detector, that is available more or less off-the-shelf. We selected for the baseline design the wedge and strip (W+S) detectors developed by the Berkeley group (Siegmund *et al.*, 1986) with 30 mm cathodes, 50 μm pixels and 500x500 pixel format. The W+S detectors are photon-counting devices whose sensitivity depends on the type of cathode and trasmission of glasses used in the window construction.

For the baseline design we configured the detectors with CsI or $CsTe$ cathodes and with windows made of suitable materials to provide cutoff wavelengths and suitable bandpasses. The payload will image in three spectral bands, of ~300Å width each, centered at 1600Å, 2200Å and 2600Å.

2.3. Data storage

A severe constraint is the communication schedule with the ground. Israel provides at present a single ground station (GS) located within its boundaries. The NSS will be seen by the GS for at most one hour per day, in a number of passes. The collected data must be stored on-board and dumped whenever the GS is in view. Thus the need for fairly large storage that conflicts with the mass and power constraints and for reasonably fast data links.

The storage medium we selected is a solid-state memory (OBM) of 60 MB, that should suffice to store one image per telescope per orbit, for an average of three orbits before downloading. In order to comply with the memory size, we have to relinquish the photon-counting option. We shall therefore store intermediate images, of some four second integration, that will be compressed by run -length coding, by a factor of ~100. Only the compressed frames will be stored in the OBM and will be telemetered to the GS, with the reconstruction of the image to be done on the ground.

3. Performance

The payload described above provides a reasonable performance in imaging faint details as well as bright objects. As an example, the event rate from the sky background, assuming a sky brightness of 25 mag/$\square''$ at the short and long bandpasses, and 26 mag/$\square''$ at the intermediate bandpass, is such that we expect to measure it with S/N~5 in a 2000 second exposure and with $10''$ pixels.

Stellar objects of UV monochromatic magnitude of 17 will be measured with a S/N~10 in a similar exposure. The brightest objects for which we expect to obtain photometric information are of UV monochromatic magnitude ~8. Diffuse objects will be detected with a S/N~5 when they are 10% or brighter than the sky background and when their size is 1□′ or larger.

The *nominal* performance of UIT is better in detecting stellar objects. However, UIT is limited by its method of recording images and by the time in orbit. TAUVEX will allow more than 5000 separate pointings during one year, that will cover about 1/3 of the entire sky. Moreover, TAUVEX will collect *simultaneous* data in the three spectral channels; this is not possible with UIT.

4. Science

A few projects were studied in some detail for the baseline Phase A mission. It appears that TAUVEX is a very good QSO detector, because of the simultaneous imaging at three spectral bands. It is possible, using the UV and visual color indices, to separate QSOs from stars. Thus we plan a survey phase early in the mission, where 1500 □° will be mapped around each galactic pole, with 10% overlap between the fields. This requires a three month period on orbit and will yield an unbiased catalog containing 6000-10000 QSOs.

The same is true for white dwarf (WD) detection; it is possible to separate WDs from normal stars using the three UV bands. We expect to compile a catalog of about 10000 WDs at the completion of the Polar Caps'survey.

Another project has to do with the star formation processes in galaxies. Here we plan to image all the Local Group galaxies, to map the entire Virgo cluster and to search for supernovae by revisiting the entire cluster after six months, and for a third time after another six months. We shall also image a sample of about 40 late-type galaxies and another of some 50 early-type galaxies.

Finally, one very interesting study has to do with fast variations in the UV emission of cataclysmic systems. TAUVEX offers the option of downloading individual photons as fast as msec rates, for objects brighter than ~12-13 UV monochromatic magnitudes and when the platform is in direct view of the GS. Thus WDs and physics of accretion disks can be studied at wavelengths close to maximal emission.

5. Status

The Phase A reports of the two competing groups were submitted to ISA at the beginning of 1990. The two proposals are now in the process of being evaluated and we expect the evaluation reports by the end of June 1990. At this point ISA shall decide which of the two experiments will proceed to Phase B (detailed design leading to the Final Design Review) and eventual construction and launch. ISA shall also decide whether to advance both experiments and fit both on the same launch.

Summary description of observatory

– The payload is the three-band UV imager proposed by Tel Aviv University and accepted for Phase A study by the Israeli Space Agency.
– The design lifetime is two years in orbit.
– The payload is 150 cm long and 50 cm in diameter. It masses 24.7 kg and consumes about 25 W. The telescope section is about 50 cm long; a 100 cm long shield reduces cold loading.
– Three 20 cm aperture R-C telescopes are co-aligned on the same platform.
– Each telescope has a FOV of 1.7° in diameter.
– Each telescope is "tuned" to a different bandpass in the UV: centers of bands are at 1600, 2200 and 2600Å .
– Detectors are of wedge-and-strip type, with *CsI* or *CsTe* cathodes, and filters.
– Images are stored in buffer memories for a few sec, then are compressed and stored in solid-state memory for later downloading.
– The sensitivity is such that a 17th mag star will be detected after 2000 sec with a S/N$\sim$10. A diffuse object that is only 10% above the sky will be detected with a S/N$\sim$5 after 2000 sec, by averaging over $10^4\square''$.

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