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Project to Map the Sky in the Infrared from an E.S.R.O. Satellite

L. Delbouille

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Project to map the sky in the infrared from an E.S.R.O. satellite

By L. Delbouille
Institut d'Astrophysique, University of Liège, Belgium

One of the experiments installed in the TD 1 E.S.R.O. satellite (expected launching date 1970), will be devoted to a mapping of the sky in the lead sulphide region. The scanning will be obtained by the motion of the satellite itself, so a relatively simple infrared photometer will be used.

Introduction

As early as 1960, on the basis of purely theoretical considerations, P. Ledoux suggested the interest of a general survey of the sky in the infrared.

In January 1962, the 'Institut d'Astrophysique' of the University of Liège and the Royal Observatory of Edinburgh, jointly proposed to COPERS (the European preparatory commission for space research) to map the sky systematically in various ultraviolet wavelength regions, from a suitably stabilized satellite. Simultaneously, following the above-mentioned suggestion of P. Ledoux, the Institut d'Astrophysique proposed to use the same optical system to make, at minimum expense, a similar experiment in the infrared. These projects were later accepted by E.S.R.O. (European Space Research Organization) and the intrumentation will be part of the payload of the TD 1 stabilized satellite, now scheduled to be launched in 1970.

The division of the work and of the responsibilities between Liège and Edinburgh is such that the Royal Observatory undertakes the design and construction of the structure, of the collecting optical system and of the spectrometer necessary for the ultraviolet experiment. The Institut d'Astrophysique takes care of the ultraviolet detectors and associated electronics. The infrared channel that we shall describe briefly is entirely the responsibility of the Institut d'Astrophysique.

If the use of the satellite is essential to mapping the sky in the ultraviolet, the same is not absolutely true in the infrared. However, considered as a 'by-product' of the larger ultraviolet experiment, the plan to make a sky survey in the near infrared seems still of interest, despite all the ground-based observations made by various observers after the first discoveries of Hall (1964). The main reason is that a single sensor will do the complete survey, with a large redundancy, in 6 months, avoiding atmospheric absorption and noise.

The scanning system

As already mentioned, the scanning will be obtained by the motion of the spacecraft along its orbit. The chosen solution is based on a study made, in 1963, by the R.A.E., Farnborough, describing an actively controlled, sun-pointing satellite constrained to rotate once per orbital period about the solar vector. Thus, if the telescope, rigidly fixed in the satellite frame, points at 90° to the solar vector, and looks away from the Earth, it will describe on the celestial sphere a great circle passing through the poles of the

Ecliptic. On the next orbit, because of the Earth's annual movement around the sun, the plane of the great circle will have rotated about the line through the Ecliptic poles. For orbital periods of 100 min, the movement of this plane is about 4 min arc. In this way a network of great circles, all passing through the Ecliptic poles and 4 min arc apart at the Ecliptic, will be scanned on the celestial sphere, the whole sky being covered in 6 months. So, for diaphragms allowing each detector to 'see' a solid angle of 4 min arc, and assuming a perfect orbit the scanned strips will just touch each other at the Ecliptic and overlap by an increasing amount towards the Ecliptic poles. In practice, a diaphragm covering 16×16 min arc will be chosen, giving a larger redundancy and allowing for small departures from the ideal orbit.

The optical arrangement

As mentioned above, the telescope has been mainly designed for similar mapping of the sky in various ultraviolet bands.

The primary mirror (aperture 275 mm, focal length 940 mm) will be used off-axis. A small mirror, placed in the focal plane of the telescope, will reflect the signal from a solid angle of 16 min arc diameter, towards the infrared sensor. This sensor will be extremely simple. A first set of lenses will form a 3 mm image of the primary mirror on the vanes of a vibrating tuning fork chopper. A second set of lenses will re-image the chopped radiation on an immersed lead sulphide cell. The temperature of this detector will be maintained around 200 °K by radiation cooling. For this purpose, one end of the infrared sensor has been brought very close to the satellite skin. The small black metallic support of the detector, placed at the apex of a reflecting cone, will radiate in the direction of the sky (away from the Sun and the Earth), through a hole in that skin. The temperature of the detector will be measured, recorded and sent to the Earth simultaneously with the measured signal. The optical filtering of the band 1·8 to 3·5 μm, approximately, will be obtained by using germanium as the material for one of the lenses, jointly with the long wavelength cut-off of the lead sulphide cell.

The lock-in system used to amplify and demodulate the detector signal will have a semi-logarithmic response, giving a nearly constant relative accuracy in a large dynamic range. On ground command, four internal sources will be sequentially switched on. These four signals, simply added to the radiation received from the sky, will be used to calibrate the sensor, as often as necessary, during its useful life.

All the signals coming from the various scientific experiments installed in the TD1 satellite, as well as many housekeeping data about the satellite itself and the signal of a real time clock will be recorded, on board, on magnetic tape and sent to the Earth once per orbit. E.S.R.O. will take care of all the data handling problems.

Reference (Delbouille)

Hall, F. F. Jr 1964 *Mém. Soc. r. Sci. Liège* **9**, 432.

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