

Soft X-ray Astronomy Payload for Use with Satellites*

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Received 9 April 1975

General system considerations for the design of a payload for observations in soft X-ray astronomy using satellites are presented. Analysis of such a system is carried out under three broad aspects: the design of a thin window gas proportional counter system with the associated collimator, the gas control unit with its electronics and the pulse processing circuitry including the telemetry interface. Based on the requirements of sensitivity and low secondary background effects as well as the constraints imposed by spinning satellites from observational standpoint, a viable system is evolved.

1. Introduction

OBSERVATIONAL soft X-ray astronomy is now recognized to be an important branch of astrophysical investigation because of the unique information it can provide on cool stars and their envelopes with typical temperatures of 10^5 to 10^6 °K, young supernova remnants, heated matter falling on to compact objects such as white dwarfs, neutron stars or black holes, as well as density, chemical composition, temperature and the state of ionization of interstellar and intergalactic media ¹⁻³.

Soft X-rays encompass an energy regime of approximately 0.1 to 1 keV which on the lower side borders on extreme ultraviolet.

The first Indian satellite has a payload for investigations in X-ray astronomy in the energy domain 2.5-100 keV. In the event of a successful launch and operation of the satellite, there is a possibility of using the second flight model of the satellite for new and worthwhile scientific experiments, besides conducting space application experiments. In this connection, the possibility of conducting a soft X-ray astronomy experiment has been explored, the details of which are given in this paper.

2. Payload Description

2.1 General

The requirements of the payload are dictated by the considerations of the spacecraft interface such as weight, volume, power and telemetry besides the primary scientific objectives. The approximate interface specifications of the payload from the point of view of the satellite are as follows:

Weight	= 16 kg
Volume	= $35 \times 16 \times 38$ cm ³
Available cutout	= 15×15 cm ²
Power	= 2 W
Telemetry	= 50 bits/sec
Stabilization	= Spin stabilization with spin rates between 5 and 11 rpm

2.2 Detector System

The detector consists of a single unit of twin thin window gas proportional counters. The window material is polypropylene of 2 micron thickness obtained by stretching a 1 mil thick sheet. Suitable carbon coating is provided for the window to suppress ultraviolet radiation contamination effects. The counter is filled with roughly half an atmosphere of P-10 gas. The effective area of each section of the counter is typically 25 cm², with a count rate of about 20 per sec, compatible with the telemetry capability. Fig. 1 shows the efficiency characteristics of a 2 micron polypropylene window counter. The counter has been tested for

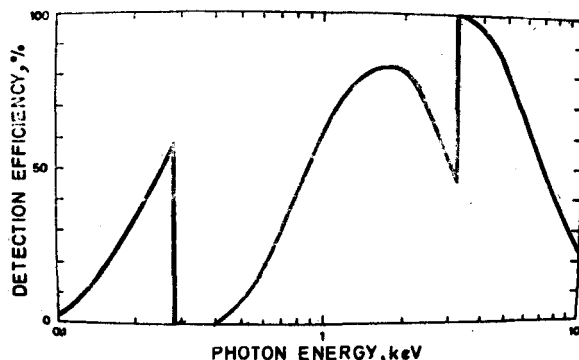


Fig. 1—Efficiency characteristics of the 2 micron polypropylene window gas proportional counter

* Paper presented at the Symposium on Earth's Near Space Environment, 18-21 February 1975, held at the National Physical Laboratory, New Delhi 110012

its response to Fe^{55} , 5.9 keV X-rays and is found to have a resolution of 18%.

2.3 Gas Regulation System

In view of the gas leakage across the thin window, and because of the sensitive dependence of the amplification factor of the counter on its pressure (amplification factor is proportional to p^8 to p^9 where p is pressure), it is necessary to have an inflight gas regulation system. The proposed regulation system is based on a capacitance pressure transducer that has a reference volume containing gas at the ambient pressure and another section connected to the counter. The capacitance change arising out of the reduction in the counter pressure is detected and converted into an error signal to actuate the solenoidal valves. Two solenoidal valves are provided so that both coarse and fine regulation controls could be realized. The accuracy of the pressure control has been measured in the laboratory and is found to be better than 1%. Fig. 2 shows a schematic block diagram of the gas regulation system. The onboard gas cylinder has a volume of 500 cc and stores gas at a pressure of 1800 psi. It is estimated that with this amount of onboard gas it will be possible to have a life time for useful observations of about 6 months.

3. Observational Techniques

The detector system will be imparted directionality using aluminium slat collimators that defines a field view of $5^\circ \times 5^\circ$. The payload will be mounted on the belly band of the satellite so that observations are possible in the scan mode as the satellite spins. The directional information, for determining the spatial distribution of X-rays, will be obtained by interfacing the detector output with digital solar sensors through

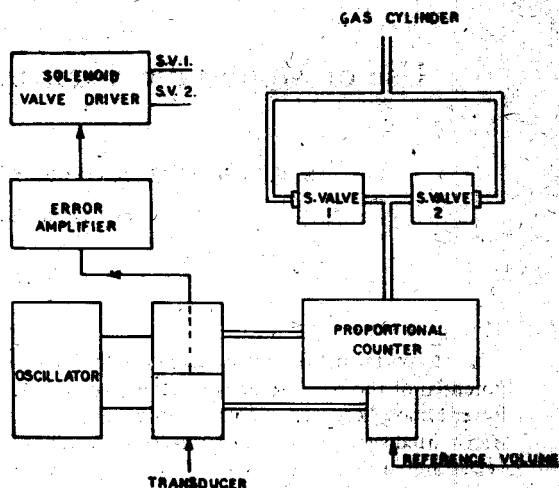


Fig. 2—Schematic block diagram of the onboard gas regulation system.

appropriate electronic gating circuits. Output of this will be fed to the onboard PCM telemetry system and will be read out serially using necessary shift registers.

4. Conclusion

An engineering model of a soft X-ray astronomy payload useful for a spin stabilized satellite has been developed. Based on the experience from this payload, a prototype model and a flight-model system will be built.

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