AN ATTEMPT TO OBSERVE ZODIACAL LIGHT AT 5μ WITH A BALLOON EXPERIMENT

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ABSTRACT

Observations of the infrared emission of the interplanetary dust enable a more direct analysis to be made of interplanetary dust material than is possible from observations of the scattered sunlight. A liquid nitrogen cooled photometer with Indium Antimonide detectors is described which has been developed for balloon-borne observations of the zodiacal light. The provision of both difference and absolute flux measurement modes will allow the observation of the zodiacal light, and the presumably much more intense emission of the high atmosphere, respectively.

INTRODUCTION

Questions about the interplanetary dust, such as its size- and spatial distribution, have been answered by several space experiments. Its chemical composition is still not sufficiently clear, however, because in the visible spectral range the scattering functions of different realistic materials do not differ enough to enable firm conclusions to be made. It is only in the infrared region that thermal emission of the dust particles, which does differ strongly for different particle materials (Röser and Staude 1978), becomes important compared to scattered sunlight.

Ground observations of the thermal emission of the interplanetary dust cloud are impossible due to the thermal emission of the earth's atmosphere. Rocket observations have been carried out by Soifer et al. (1971) and by Briotta et al. (1976), but these are possibly affected by earth light according to the opinion of Röser and Staude (1978). These athors consider the measured intensities as upper limits because they are considerably higher than the radiation assigned to their most intensely emitting model cloud, a graphite particles cloud. Other calculations of Frazier (1977), can, with some fitting, explain the spectrum observed by Briotta et al. (1976) with a model of dirty Obsidian particles.

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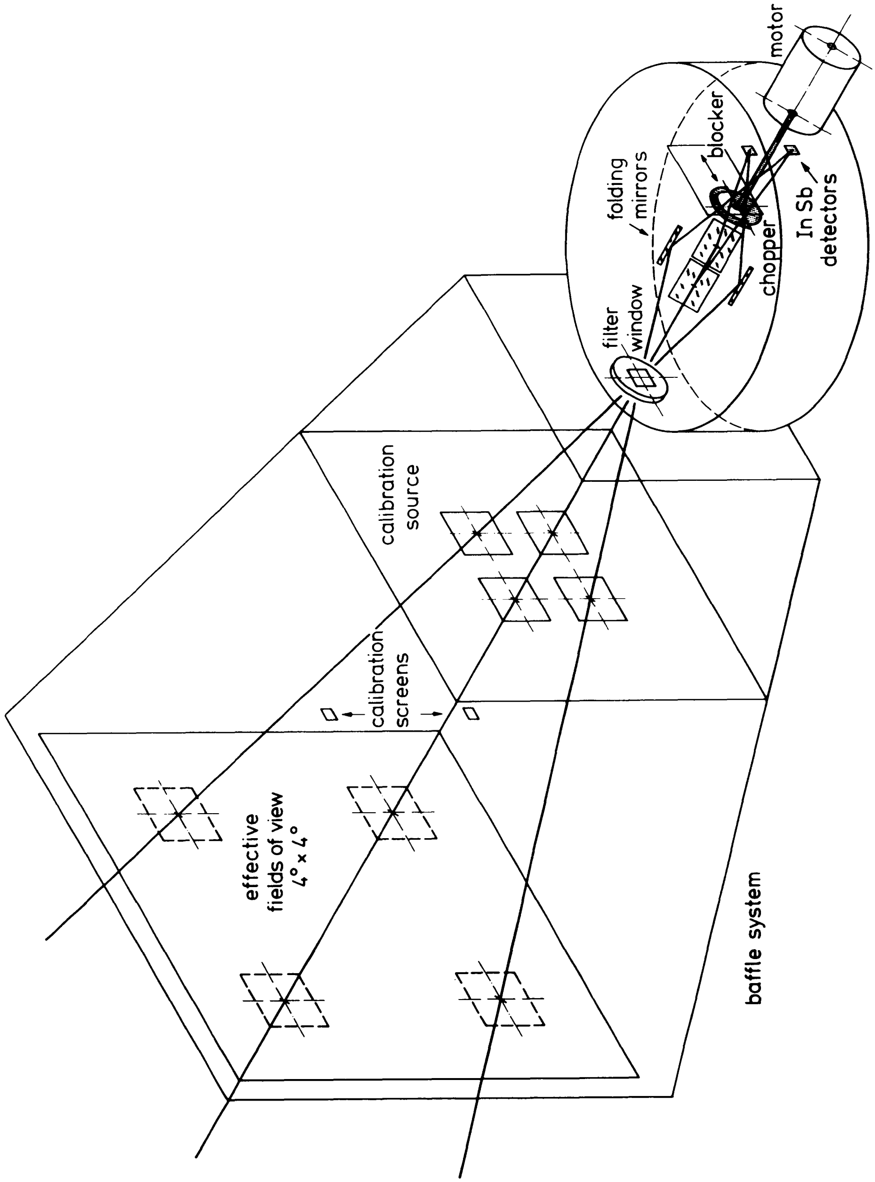

Figure 1. Schematic view of the 5 μ photometer.

This attempt to measure the thermal emission of the interplanetary dust with a balloon instrument started with first considerations of Frey (1976). Based on the observed spectrum of the emission of the Earth's high atmosphere by Bunn and Gush (1970) and on calculations of Traub and Stier (1976) he estimated the atmospheric emission at balloon altitudes to be 4.10^{-8} W cm^{-2} sr^{-1} μ^{-1} which is about 3 decades more than the intensity of a medium zodiacal light model of Röser and Staude (1978) at 30° elongation in the ecliptic. Whether a determination of the zodiacal light intensity is possible by chopping rapidly between two fields, one in the ecliptic and close to the sun, the other far out of it, will depend on the angular distribution and the noise of the atmospheric emission.

INSTRUMENT

Because of the smooth brightness distribution of the zodiacal light, imaging optics were omitted. The beam size of 4° x 4° is defined by the sizes of the aperture and the detector and their distance from each other. Beam and reference beam are separated by 20° and chopped by a rotating sector disc (10 Hz). The reference beam can be blocked by a "blocker", allowing total flux measurements. Beam and reference beam enter the photometer through the same window and aperture, avoiding optical offsets due to otherwise slightly different size, transmission or emissivity of the optical elements. This design necessitates additional folding mirrors (see figure). The window is also the interference filter which, together with the spectral sensitivity of the detector defines the spectral bandpass (0,8μ) of the instrument. The photometer is cooled to the temperature of liquid nitrogen and has no warm optical components whatsoever.

This simple optical design allows the simultaneous operation of a second symmetric photometer, 20° apart from the first one (see figure). Common to both photometers are the window with aperture and the chopper. The two main beams and the two reference beams cross each other in a plane where the chopper is operated.

The largest available Indium Antimonide detectors (5mm x 5mm) were chosen because, for a surface brightness such as the zodiacal light, the increase in detector noise is more than compensated by the signal increase, which is proportional to the detector area.

A baffle system is mounted in front of the photometers to protect the window from radiation from the earth and from the balloon. For instrument elevations larger than 20° radiation from layers more than 30 km below the flight height can only penetrate into a first baffle room. A total of 4 diffuse reflections on the black walls of the baffle system are necessary before the stray light can hit the window. The same attenuation holds for radiation from the balloon at instrument elevations of less than 60°. The baffle system itself is cooled with dry ice. The temperature drops in flight below -100°C. In spite of the low thermal emission at this temperature the design of the baffle system does not allow the beams to touch the baffle edges. The baffle system can be closed during test and launch and also flushed with dry nitrogen.

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A hot wire in the baffle system serves as calibration source. When switched on it illuminates each of two small screens in the corners of the two main beams of the photometers.

The sensitivity of the detector, given by its NEP of $7 \cdot 10^{-14}$ W $Hz^{-1/2}$, is in the order of that required to detect the zodiacal light. With 4° x 4° field of view, a detector area of 0,25 cm^2, a bandwidth of 0,8 μ and 50% transmission an intensity of about $2{,}5 \cdot 10^{-10}$ W cm^{-2} sr^{-1} μ^{-1} should be detectable with a 1 Hz bandwidth. The brightest model cloud of Röser and Staude (1978) (graphite model) has about this intensity at 30° elongation in the ecliptic.

The instrument is mounted in the balloon gondola THISBE (Lemke et al. 1976). The first flights should determine the feasibility of observing the zodiacal light through the emission of the high atmosphere.

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Discussion

Reply to S.F. Singer: Calculation of the thermal emission of dust particles may be found in Röser and Staude, Astron. Astrophys. 67, 381 (1978).

Reply to Ph. Lamy: The instrument will observe in azimuth scans close to the horizon while the sun is about 20° below the horizon. We hope to reach 30° elongation. Because the path of the balloon is determined by winds it is not feasible to do an experiment during a total eclipse.

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