SOLAR SPECTRUM FROM 180 TO 3200 nm

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The scientific aims of this investigation are (1) the measurement of the absolute solar spectral irradiance in the wavelength interval 180-3200 nm and (2) the measurement of the possible long-term variation of the solar spectral irradiances. This experiment will be on board Spacelab 1, which will be launched by the Space Shuttle in May 1983. It has also been selected for the other Spacelab flights dealing with solar irradiance observations and upper atmospheric physics.

Basically, the instrument is composed of three double monochromators of 10 cm focal length, using holographic concave gratings as dispersive optics. A brief description of the instrument has been presented at the Fifth Workshop on the VUV Radiometric Calibration of Space Experiments (Simon, 1979) and at the 14th ESLAB Symposium on Physics of Solar Variations (Thuillier et al., 1980).

The main characteristics of the instrument are as follows:

1. The six gratings are mounted on the same mechanical shaft.
2. The ultraviolet and visible monochromators have an overlap in their wavelength ranges, as do the visible and the infrared monochromators, as well.
3. Transmitting diffusors are placed in front of the three entrance slits.
4. The bandpass is 1 nm in the ultraviolet and the visible wavelength ranges and 20 nm in the infrared.
5. In-flight calibration sources are integrated in the instrument in order to check its behavior during the different ground operations and in orbit.

Both scientific aims cannot be reached without a careful radiometric calibration procedure. Indeed, the accuracy requested for aeronomy, climatology, and solar physics varies from 5 percent around 200 nm to 1 percent in the visible and infrared parts of the solar spectrum. In addition, the quantitative measurement of the long-term variations of the solar irradiance requires observations with a precision of 1 percent in the ultraviolet and 0.3 percent in the visible and infrared.

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The main advances in using Spacelab are to allow an in-flight calibration during the solar observations in orbit and a post-flight calibration after a limited stay in space (1 week). Consequently, two general problems could probably be solved using such a platform: the validity in the space environment of the ground calibration performed before the flight and the aging effect on the instrumental sensitivity in orbit during the solar observation.

THE IN-FLIGHT CALIBRATION

In this investigation, two deuterium gas discharge lamps (for the ultraviolet) and two tungsten ribbon lamps (for the visible and the infrared) will be mounted above the frontplate of the monochromators. The purpose of these lamps will only be to check the stability of the instrument sensitivity, especially in orbit, comparing the signals obtained with the same sources before, during, and after the flight. The lamps themselves will also be compared with the "long time standards," used for the laboratory calibrations and described below, in order to detect any changes in their radiometric characteristics.

The radiating surfaces of these sources will be imaged by means of an optical system (lenses) on the corresponding transmitting diffusor in front of the entrance slit. The diameter of the lenses has been chosen so that the irradiation fluxes coming from the lamps are nearly equal to the corresponding solar irradiances. The lamps are fixed and the temperature, voltage, and current of each lamp will be monitored and recorded for each run of the instrument. A more complete description of the deuterium lamps has been published by Finkenzeller and Labs (1979).

In order to check, in orbit, the spectral apparatus profile as well as the wavelength scale of the stepping motor driving the grating rotation, one hollow cathode lamp has also been added in the in-flight calibration device.

THE GROUND CALIBRATION

The absolute calibration of the complete spectroradiometer will be performed using the radiation emitted by a black body working at a temperature of about 3000 K. The distance between the black body radiation surface and the transmitting diffusor will be chosen so that the solid angles for the black body being seen from the instrument and for the sun are very similar. Such calibration facility would permit the following radiometric uncertainties to be reached, depending on the wavelength range:

Wavelength range (nm)	Uncertainties
$\lambda < 250$	± 5%
$250 < \lambda < 300$	± 3%
$300 < \lambda < 400$	± 2%
$400 < \lambda$	± 1%

Consequently, the requirements on the accuracy for the solar irradiance values between 180 and 3200 nm are fulfilled.

As this calibration can be made only in the laboratory and will take place a long period of time before the launch, it is absolutely necessary to check the instrumental stability during all the tests and the integration phases of the experiment. On the other hand, the post-flight calibration should be carried out as soon as possible after landing. In addition, the reproducibility of the calibration with the black body is of the same order of magnitude as its accuracy. Therefore, the determination of the long-term variations of the solar irradiances requires a more stable relative radiometric scale, of the order of 0.1 percent in the visible, over at least ten years.

For these purposes, two sets of lamps will be used: ten tungsten ribbon lamps (type W17G-OSRAM) for wavelengths beyond 250 nm and ten deuterium lamps (type HANAU D 60, end on) for wavelengths below 350 nm. Five lamps of each type will be kept carefully in the laboratory, the others traveling with the instrument for "real-time" calibration checks.

The tungsten ribbon lamps have been used since the 1960's in the Heidelberg laboratory. Their radiation intensity can be kept stable within about 0.2 percent for 100 hours of burning time if they are operated with an AC power supply. The deuterium lamps have been studied already in Heidelberg and an interlaboratory comparison has been published by Bridges et al. (1977). The flux stability of this kind of ultraviolet source is of the order of 3 percent for 100 hours of burning time. In addition, any change of their irradiance scale can be detected by comparison with the tungsten ribbon lamps in the wavelength interval 280-350 nm, corresponding also to the overlapping range of the ultraviolet and the visible monochromators.

The use of the two sets of five lamps allows the checking of any unusual aging of the calibration sources, which can occur during the period required to measure the long-term variation of the solar irradiance. Indeed, two lamps of each set will be burned for only very short periods of time, the others being used as working standards. In addition, they will be calibrated on an absolute scale against the black body, using the instrument itself for this transfer. Consequently, any correction in the future of the absolute radiometric scale can be taken into account. Furthermore, intercomparisons with other radiometric scales are highly desirable. For instance, the instrument will also be calibrated at the National Bureau of Standards, using the SURF II facility described by R. P. Madden in this proceedings.

REFERENCES

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