light from the earth's twilight/dawn horizon. In fact, because of the orbit characteristics, it was anticipated that severe solar constraints would dramatically reduce the useful observing time. In the best case (revolution 84), the lowest elevation of the sun below the orbiter horizon was $-7.3°$; it was only $-3.4°$ at the end of the VWFC observing time (revolution 98). Other possible sources of stray light (such as the Cerenkov effect, fluorescence, and shuttle glow) are being investigated.

Results. Despite the poor orbital conditions for deep astronomical observations, excellent ultraviolet pictures were obtained on the southern Milky Way and on the region of the Large and Small Magellanic Clouds (LMC and SMC). The photographs with the longest exposure (300 seconds) show up to 6000 stars down to magnitude $m_{1930} = 9.3$. They will provide a good basis for searching for peculiar ultraviolet objects and for the quantitative study of apparently normal B stars at high galactic latitude.

The most striking feature revealed by the observations is a faint extension of the well-known Shapley wing of the SMC (*4*). Two photographs at 1650 Å and two others at 1930 Å (Fig. 1) show a patchy, diffuse, elongated area pointing in the direction of the LMC. This region is centered at right ascension $\alpha = 2$ hours, declination $\delta = -74°30'$ and is about 1° by 2° in size. Its ultraviolet contour agrees well with visual deep photographs (*5*) and star counts (*6*), which have shown that blue stars are the major constituent of this region. This has been further confirmed by the observations from the S2/68 sky survey telescope (*7*). In addition, faint Hα emission has recently been observed in the direction of the brightest part of the ultraviolet feature, with an Hα radial velocity of 130 ± 20 km/sec (*8*), in good agreement with stellar radial velocities (*9*). Also, comparison with the distribution of neutral hydrogen in the Magellanic system (*10*) shows that the ultraviolet emission area is located at a steep gradient of the 21-cm emission, as is commonly the case for OB associations and H II regions in external galaxies.

The VWFC observations have thus yielded the ultraviolet image of a cloud (approximately 1.2 by 2.4 kiloparsecs) of hot stars which is a part of the interconnecting bridge between two galaxies.

G. COURTÈS, M. VITON, J. P. SIVAN
Laboratoire d'Astronomie Spatiale, CNRS, Marseilles, France
R. DECHER, A. GARY
Marshall Space Flight Center, Huntsville, Alabama 35812

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12. We are deeply indebted to the numerous technical teams which contributed to the success of the experiment, in particular, to personnel at NASA, the European Space Agency, Centre National d'Etudes Spatiales, and Laboratoire d'Astronomie Spatiale, and to the Spacelab 1 crew.

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Solar Irradiance Observations

Abstract. *The absolute radiometer on Spacelab 1 was used to obtain solar irradiance observations from space. A number of effects must be taken into account in the data reduction. A provisional value was obtained for the mean solar constant during the observation period (6 to 8 December 1983).*

The solar irradiance is the total flux normally incident on a unit area at the place of observation. The solar constant or solar irradiance at 1 AU is a basic parameter for the understanding of the earth's climate. As a measurement of the solar luminosity it is a basic parameter for solar physics.

Because of the difficulties in correcting for absorption by the earth's atmosphere, the solar constant can be determined only to within about 2 percent when measured from ground-based observatories. Only measurements made from outside the atmosphere reach the precision needed to determine variations that are smaller than 1 percent. Measurements from satellites, in particular Nimbus 7 (*1*) and the Solar Maximum Mission (*2*), have shown that the solar irradiance can vary up to about 0.1 percent over periods on the order of one solar rotation. At least some of the solar irradiance variation is related to blocking of the solar surface by sunspots. However, the observed long-term variations of the solar irradiance are difficult to interpret from free-flying spacecraft alone, possibly because of aging effects in the instrumentation.

In an attempt to measure the variability of the solar constant over a period of the order of a solar cycle (~11 years), we plan to fly, once a year, a single type of instrument which gives an absolute value of the solar irradiance, and to compare the results with those from well-kept instruments on the ground before and after the flight. Our measurement from Spacelab 1 is the first in this series. Moreover, the difficulty of obtaining instruments that are sufficiently stable and precise is so great that it is recommended that more than one instrument of different design be operated simultaneously and the results compared (*3*).

Measurement technique. The principle of the absolute radiometer (*4*) is based on the comparison of radiative energy to electrical energy generated by

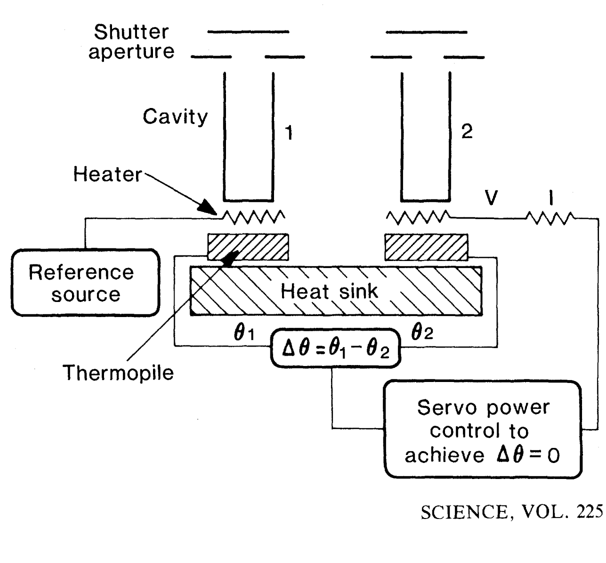

Fig. 1. Schematic diagram of radiometer showing the main components: θ_1 and θ_2, heat fluxes detected by thermopiles; V, voltage at leads of heater resistance in channel 2; I, current through heater in channel 2.

the Joule effect. The absolute radiometer is an improved version of the radiometer built at the Royal Meteorological Institute of Belgium. It is one of three radiometers that constitute the World Radiation Reference, an internationally agreed standard in radiation metrology. It consists of two heat flux meters which are mounted on a common thermal heat sink and are provided with identical absorbing cavities and heating elements. A calibrated aperture and a shutter are mounted in front of each channel. A baffle limits the view angle of each channel to less than 10°. A diagram of the main elements of the radiometer is shown in Fig. 1. The radiometer continuously achieves a thermal balance between the two channels while converting the solar energy to electrical energy in one of them.

With both shutters closed, reference power is applied to channel 1. The heat flux detected by thermopile 1, θ_1, is compared electronically with the heat flux detected by thermopile 2, θ_2, so that

$$\Delta\theta = \theta_1 - \theta_2$$

This difference is the input to a servo system, which modifies the power provided to the heater of channel 2 until $\Delta\theta = 0$. The voltage, V, at the ends of the heater resistance and the current, I, give a measure of the power applied to channel 2, W_{closed}. With the system in equilibrium, the shutter of channel 2 is opened and the solar radiation that passes through the aperture heats the cavity of channel 2. The servo system continues to adjust the power in heater 2 to achieve the same heat flux as in channel 1, and the new measurement of V and I gives a power value in channel 2, W_{open}.

The difference $W = W_{\text{closed}} - W_{\text{open}}$ in the power supplied to channel 2 with shutter closed and shutter open is proportional to the solar radiation that has passed through the aperture. In the actual experiment, channels 1 and 2 are interchangeable, that is, the reference and the servo system can be applied to either side. The servo system used in Spacelab 1 has a response time of 4 seconds to reach 0.1 percent of a power step applied to side 2. Figure 2 shows a cutout view of the radiometer. The electronics, located in the box below the radiometer, includes the servo system, data and control electronics, analog-to-digital converters, and shutter control circuits. The radiometer is 45 cm high and has a square base 16 cm on a side. With its power converter, its weight is 6.63 kg. It was the lightest payload element on the pallet of Spacelab 1.

For the radiometer to be absolute it is necessary that the measurements obtained are based solely on the knowledge of its mechanical, electrical, thermal, and optical characteristics; any calibration based on the utilization of a radiation source or the use of another reference detector is excluded. This implies that all the nonequivalence parameters originating from the comparison of electrical and radiative power sources that are different in nature must be characterized. For that reason, the laboratory for absolute radiometric measurements of the Royal Meteorological Institute has been equipped with an installation where these determinations can be made either in air or in vacuum with a high-stability laser source. The nonequivalence parameters take account of the difference in response of the radiometer to the solar radiation that passes through the aperture and to the electrical power that substitutes for it when the shutter is closed.

The nonequivalence corrections to be applied to the electrical measurements are those for:

1) Radiation emitted to the sensor by the shutter of the exposed channel,

2) Diffraction from the front aperture of the radiometer,

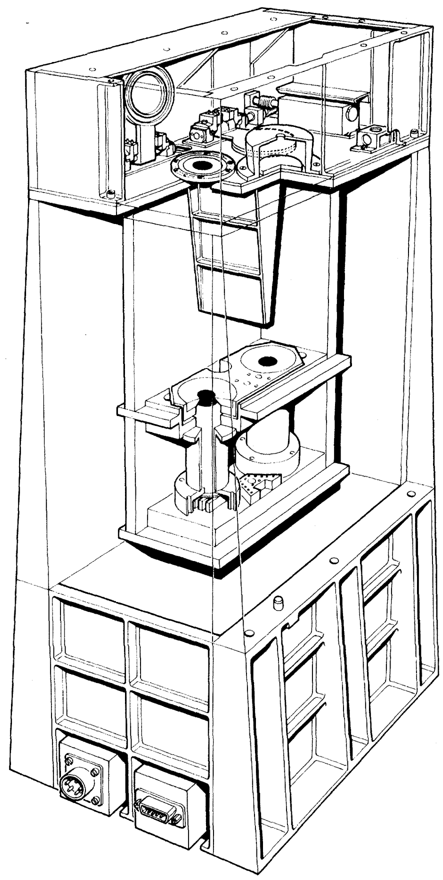

Fig. 2. Cutout view of the radiometer unit.

3) Diffusion or scattering by the edge of the front aperture,

4) Radiation trapped in the view-limiting enclosure that reaches the detector after several reflections,

5) Thermal effects of the trapped radiation referred to in 4,

6) Surface sensitivity of the bottom of the cavity,

7) Efficiency of the cavity,

8) Dissymmetry of the electrical power generated in the leads connected to the heaters,

9) Effective absorption coefficient of the cavity and the coating, and

10) Temperature sensitivity of the aperture area of the measuring sensor.

Effects 5, 6, and 7 are different in air and in vacuum; knowledge of these effects is based on characterization as well as effects 3, 4, 8, and 9. Effect 2 was calculated by Brusa (*5*), and effect 1 was calculated and cross-checked during flight. In addition to these radiometric features, proper operation of the radiometer is based on thermal calibration of the analog-to-digital converters and temperature sensors.

Preliminary results. At the time of submission of this report the recorded data were not yet available to us; hence, an evaluation has been made based on partial data obtained in real time during flight. On this basis, we obtain for the mean solar irradiance at 1 AU a value probably between 1361 and 1365 W/m^2, which is on average about 0.5 percent lower than the value obtained by Hickey (*6*) on Nimbus 7 at the time of the Spacelab 1 flight. After the recovery of the instrument the analog-to-digital electronics was recalibrated, and a comparison with radiometers kept on the ground for reference will be made at a mountain site. After the completion of these consistency and stability controls, the recorded data will be used to obtain a final set of results with reduced error.

D. CROMMELYNCK
Royal Meteorological Institute, B-1180 Brussels, Belgium

V. DOMINGO
Space Science Department, European Space Agency, European Space Research and Technology Centre, 2200 AG Noordwijk, Netherlands

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