**References and Notes**

1. See J. Bixler *et al.*, *Science* **225**, 184 (1984).
2. The principal characteristics of the Spacelab 1 x-ray spectrometer are as follows: collimator field of view (movable +8° to −7°), 4.5° full width at half-maximum (FWHM); peak collimator transparency, 90 percent; nominal energy range, 2 to 40 keV; available energy range, 2 to 80 keV; number of channels per energy range, 500; background rejection efficiency (2 to 10 keV), 97 percent; background rejection efficiency (10 to 20 keV), 96 percent; x-ray acceptance efficiency $A_x$, 80 percent; background after rejection (2 to 10 keV), 0.4 count $sec^{-1}$ $keV^{-1}$; background after rejection (10 to 20 keV), 0.5 count $sec^{-1}$ $keV^{-1}$; total geometric area for photoabsorption of x-rays (includes collimator peak transparency and $A_x$), 183 $cm^2$; energy resolution (FWHM) ($E$ < 25 keV), $27/E(\text{keV})^{1/2}$ percent; $K$ escape fraction above 34.5 keV, 58 percent; $L$ escape fraction above 4.5 keV, 2 percent.
3. R. D. Andresen *et al.*, *Adv. Space Res.* **2** (No. 4), 281 (1983).


27 March 1984; accepted 5 June 1984

# Very-Wide-Field Ultraviolet Sky Survey

Abstract. *Very-wide-field photographs of the sky were taken on Spacelab 1 at 1650, 1930, and 2530 angstroms with a limiting magnitude of 9.3 at 1930 angstroms. A 1.2 by 2.4 kiloparsec ultraviolet extension of the Shapley wing of the Small Magellanic Cloud is seen in some of the photographs.*

Astronomical observation of very extended phenomena, such as the zodiacal light, the Milky Way as a whole, or the extragalactic sky background, requires very wide fields of view. With very large fields it is possible to compare the brightness of the extended source with the limit brightness of the sky background on the same exposure. Ground-based observations with very-wide-field, high-luminosity cameras have proved useful in the detection of galactic nebulae of large angular diameter and faint surface brightness (*1*). At ultraviolet wavelengths a wide field (80° by 120°) in the northern Milky Way was photographed at 2650 Å (*2*), but most ultraviolet space observations have been performed with scanning techniques, which have the disadvantage that it is necessary to deal with the difficulty of image reconstruction.

Experiment 1ES022 on Spacelab 1 was designed to carry out a deep, large-scale imaging survey of a large portion of the celestial sphere at ultraviolet wavelengths. The main objective of this survey was to obtain new information (photometric, morphological, and spectrographic) on the large-scale distribution of (i) stellar ultraviolet radiation in the Milky Way and the nearest galaxies, (ii) scattering dust clouds in and above the galactic plane, and (iii) sunlight scattered by interplanetary dust (zodiacal light). The survey was also expected to be useful in the detection of ultraviolet stars and starlike objects.

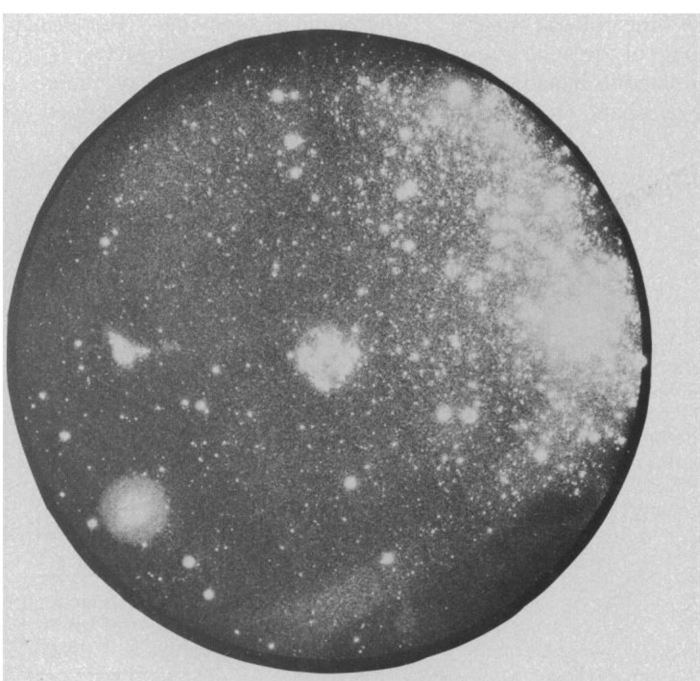
*Instrument*. The very-wide-field camera (VWFC) devised for the Spacelab 1 mission has been described (*3*). In the photometric mode, an all-reflection *f*/1.9 Schmidt camera refocuses the image of the sky from a hyperbolic primary mirror onto the photocathode of a 40-mm, proximity-focused ITT intensifier. The overall useful field is 66° in diameter and the angular resolution is 5 arc minutes, a value compatible with the guiding performance of the orbiter. Three interference filters can be placed across the entrance pupil of the Schmidt camera. They are centered at 1650, 1930, and 2530 Å with bandwidths at half-maximum of 400, 250, and 250 Å, respectively.

By using a holographic grating in place of the filters, the camera may be operated as a large-field (14° by 6′) nebular spectrograph (spectrographic mode). The observed spectral range extends from 1400 to 2900 Å with a spectral resolving power of 700 at 1900 Å.

*Observations*. The VWFC was mounted in the Spacelab scientific air lock. It was operated during the nights of revolutions 84 to 91, 94 to 96, and 98. Each sequence of exposures was initiated by the crew and completed automatically under computer control. The whole program for the 28 November launch was achieved nominally. A total of 48 exposures were obtained for ten astronomical targets. Six additional exposures on the earth airglow were made during revolution 105.

Because of the delayed launch date, only about 40 percent of the original VWFC scientific program was achieved. The delayed program did not permit observation of the zodiacal light and considerably shortened the orbital night durations.

Most of the photographs obtained during the Spacelab 1 mission suffer from a high level of sky background. The main contributor to this background is stray



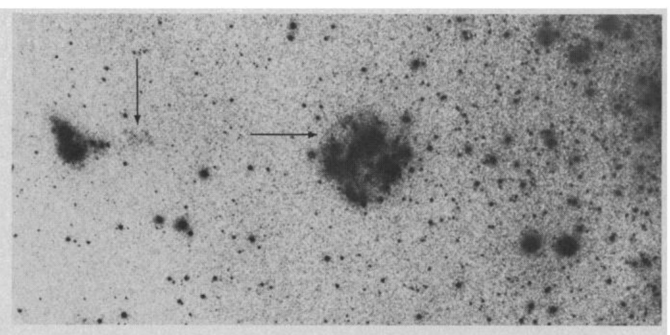


Fig. 1. (Left) Positive print of a 66° field, 300-second exposure taken by the very-wide-field camera at 1930 Å. The field is centered on the Large Magellanic Cloud (LMC). The Milky Way is on the right and the Small Magellanic Cloud (SMC) is on the left. Below the SMC is the very bright star α Eridani. This picture shows on the right side of the SMC a 1° by 2° region of faint emission, pointing toward the LMC, which is interpreted as a large cloud of hot stars in the interconnecting bridge of matter between the SMC and the LMC. (Right) Negative enlargement of the central part of the upper photograph showing the two Magellanic Clouds and the ultraviolet extension of the Shapley wing of the SMC (vertical arrow). Note also in the upper left part of the LMC a very thin arc-shaped feature (horizontal arrow) previously observed at 2000 Å by the Marseilles-Geneva balloon-borne telescope (*11*).

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.

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**References and Notes**

1. J. P. Sivan, *Astron. Astrophys. Suppl.* **16**, 163 (1974); G. Courtès, J. P. Sivan, M. Saisse, *Astron. Astrophys.* **97**, 334 (1981).
2. J. P. Sivan and M. Viton, in *Ultraviolet Stellar Spectra and Ground-based Observation*, L. Houziaux and H. E. Butler, Eds. (Reidel, Dordrecht, 1970); G. Courtès, M. Laget, J. P. Sivan, M. Viton, A. Vuillemin, H. Atkins, *Philos. Trans. R. Soc. London* **279**, 401 (1975).
3. G. Courtès, P. Cruvellier, M. Detaille, M. Saïsse, *Prog. Opt.* **20**, 1 (1983).
4. H. Shapley, *Harvard Bull. 914* (1940), p. 8.
5. G. de Vaucouleurs and K. C. Freeman, *Vistas Astron.* **14**, 163 (1972).
6. B. E. Westerlund and J. Glaspey, *Astron. Astrophys.* **10**, 1 (1971); M. T. Brück, *ibid.* **68**, 181 (1978).
7. D. H. Morgan and K. Nandy, *ibid.* **70**, 785 (1978).
8. Observations carried out in the European Southern Observatory in February 1984 by J. Boulesteix *et al.* (personal communication).
9. N. Carrozzi, Y. Peyrin, A. Robin, *Astron. Astrophys. Suppl.* **4**, 231 (1971).
10. D. S. Mathewson and V. L. Ford, preprint.
11. B. Milliard, thesis, University of Provence, Marseilles (1984).
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.

27 March 1984; accepted 10 May 1984

## 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

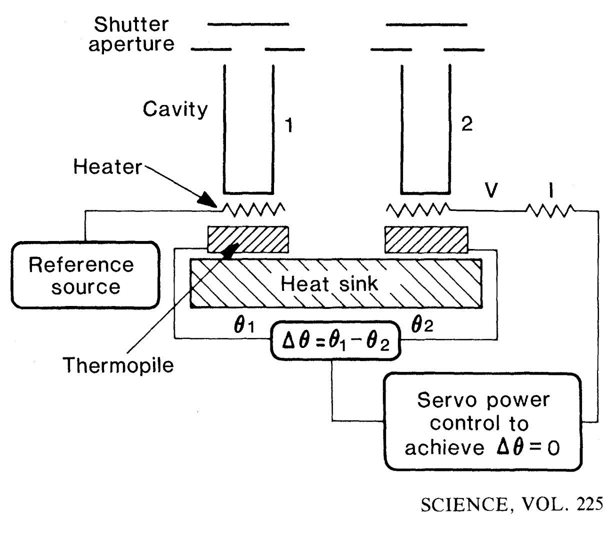


Fig. 1. Schematic diagram of radiometer showing the main components: $\theta_1$ and $\theta_2$, heat fluxes detected by thermopiles; *V*, voltage at leads of heater resistance in channel 2; *I*, current through heater in channel 2.