measurements looking forward into the velocity vector away from the vehicle. The field of view of the instrument is very small (0.65° by 0.01°) and thus it looked tangentially away from the earth at 250 km with no possibility of viewing either shuttle surfaces or the earth or lower atmosphere. The measurements were made under sunlit conditions, with the plane of the orbit close to the terminator. The experiment was designed to look into possible emissions associated with atmospheric interactions with surfaces or shuttle environment (*5*). A significant enhancement was found to exist longward of 6000 Å, as shown in Fig. 4. The enhancement consists of a number of different overlapped molecular bands, which are in the process of being identified. The spectrum was found to be noticeably lacking in atomic features. One of the theories proposed to date to explain shuttle glow effects involves a plasma discharge mechanism, with the source of the emission being impact by energetic electrons (*6*). The spectra show pronounced N_2^+ first negative bands, which might at first appear to support this theory except that the N_2 second positive system, which has a large cross section for impact excitation, is practically if not completely missing. This is illustrated in Fig. 5. A mechanism must thus be found which is capable of ionizing N_2 while not exciting the second positive system. This topic will be discussed in greater detail elsewhere (*7*).

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Sample Performance of the Grille Spectrometer

Abstract. *The grille spectrometer observed the setting and rising sun 18 times during the Spacelab 1 mission. In addition to solar absorption lines, many of which had not been observed before, atmospheric spectral absorptions due to carbon monoxide and carbon dioxide were observed at heights tangent to the thermosphere (greater than 85 kilometers), and absorptions due to ozone, water, methane, and nitrous oxide were observed in the mesosphere (greater than 50 kilometers). The strongly coupled molecules NO-NO_2 and HCl-HF were observed as pairs in the stratosphere. Methane is presented as an example of the instrumental operations because of the characteristic aspect of the* Q *branch of its v_3 band.*

Infrared absorption spectrometry of the atmosphere, using the sun as a light source at sunrise or sunset, has for the past 15 years proved to be a powerful method of studying vertical distributions of trace species (*1*). The largest possible amount of light-absorbing molecules is observed on the optical path tangent to the earth's surface at various altitudes, allowing the deconvolution of very low concentrations as a function of altitude. A great deal of information has already been gathered with this method from high-altitude platforms such as aircraft and balloons. An orbiting platform provides access to higher altitudes and to nearly global coverage. Whereas with high-altitude platforms the earth's rotation provides altitude scanning at sunrise or sunset, scanning is achieved at a much higher rate from an orbiting spacecraft. Such fast spectral scanning requires a high-throughput instrument.

The choice of instruments satisfying the requirements for scanning from orbit is limited (*2*). The grille spectrometer (*3*) is well adapted, as demonstrated by the first Spacelab flight. A single grille mounting was selected to act as entrance and exit light ports for the spectrometer. The instrument and its operation (*4*) are described briefly as follows.

The optics consists of a two-axis steerable frontal plane mirror which tracks the sun in front of a Cassegrain telescope with aperture 30 cm and focal length 6 m. The sun is imaged on the grille, which intercepts a square portion of the solar image (8 arc minutes). The spectrometer has a grating of 59 grooves per millimeter, which is illuminated by a parabolic mirror oscillating at 436 Hz with an amplitude of ±20 arc seconds; the position of the mirror is controlled within 5 arc seconds. The exit light flux, split into two beams, passes through interference filters to two detectors (InSb, 2.5 to 5.5 μm, and HgCdTe, 2.5 to 10.5 μm). The spectral resolving power is 1.3×10^4 (instrumental line width at half peak height).

The electronics in the Spacelab module links the pallet instrument to the Command and Data Management System (CDMS) and the high-rate multiplexer (HRM). Using data originating from the orbiter (time, attitude, and orbit parameters) and from Spacelab (time line, onboard and ground commands, sun ephemeris), it manages the execution of the stored measurement programs, including inflight updating. The electronics on the pallet instrument provides the functions of electromechanical control and signal detection and formatting. The main role of the crew was to check the instrument wavelength calibration, spectral resolution, and sensitivity by monitoring the display of a calibration spectrum generated inside the spectrometer with a calibration lamp shining through a gas cell. The mission specialist in charge of this task performed a wavelength alignment 12 hours after launch.

The pallet instrumentation weighed 122.8 kg, was 1.8 m high, and occupied 0.7 m^2. The weight of the module equipment was 15 kg. The data rate in operation was 51.6 kilobits per second.

Twenty-five solar occultation runs were allocated for this experiment on Spacelab 1. Because of the launch window time-season combination the runs were scheduled in the first days of the mission since the full orbit was in sunlight during the last 5 days. Observations at sunset took place in the northern hemisphere at latitudes ranging from 56°

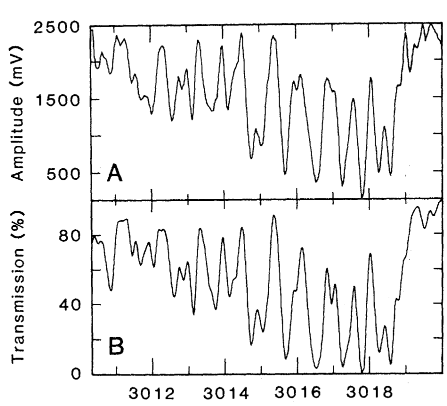

Fig. 1. (A) Spectrum of the *Q* branch of the 3.3-μm band of CH_4 recorded in 2 seconds on 3 December 1983 at 3 hours, 47 minutes, 49 seconds Greenwich mean time. The signal amplitude is plotted against wavenumber. (B) Synthetic spectrum of the same absorption feature computed with the Air Force Geophysical Laboratory molecular parameters (*5*) and the CH_4 vertical distribution deduced from the spectra.

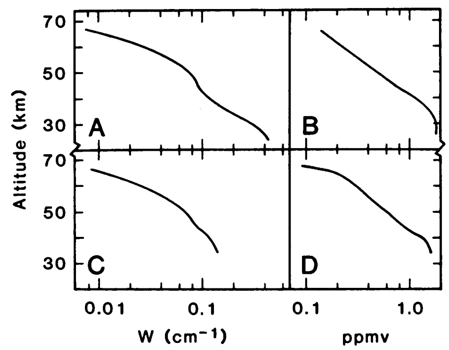

Fig. 2. (A) Equivalent width, W, of the absorption feature at 3017.8 cm^{-1} as a function of tangent altitude of the line of sight to the sun center. (B) Inverted CH_4 volume mixing ratio computed on the basis of the U.S. standard atmosphere (1966) for the atmospheric temperature and total number density profile versus altitude. (C) Equivalent width of the 2979-cm^{-1} CH_4 manifold versus tangent altitude. (D) Deduced CH_4 vertical distribution (ppmv, parts per million by volume).

to 30°. The sunrise observations took place at high southern latitudes and provided pertinent information on interhemispheric seasonal variations of the observed atmospheric species, such as thermospheric CO.

In addition to solar infrared absorption features, many of which had not been observed before, atmospheric spectral absorptions due to CO and CO_2 were observed at heights (H) tangent to the thermosphere ($H > 85$ km); absorptions due to O_3, H_2O, CH_4, and N_2O were observed in the mesosphere ($H > 50$ km); and the strongly coupled molecules NO-NO_2 and HCl-HF were simultaneously observed in the same stratospheric regions. In this report we present the first results on methane in the mesosphere, where it had not been measured before.

Since its only atmospheric source is at ground level, methane has been used by atmospheric modelers as a vertical transport indicator. Its increasingly efficient oxidation at higher altitudes in the stratosphere leads to a continuous reduction of its volume concentration with altitude. Methane absorptions were observed from Spacelab in three sunset runs at two different spectral intervals in the 3.3-μm ν_3 fundamental band. A spectrum of most of its Q branch, recorded in 2 seconds while the line of sight to the sun center grazed an altitude of 26 km above the geoid, is shown in Fig. 1A. Figure 1B shows a synthetic spectrum of the same spectral region computed with the results of the inversion of the measured absorptions.

Figure 2A shows the measured equivalent width of the absorption feature at 3017.8 cm^{-1}. It is essentially due to five absorption lines, whose parameters (*5*) have been used to deduce the vertical distribution shown in Fig. 2B. This result was verified with synthetic spectra of the whole region except below ~30 km, where slightly lower values are obtained; this discrepancy could originate from the saturation of these lines at very low altitudes. Figure 2C shows the equivalent width of the CH_4 manifold centered at 2979 cm^{-1} as a function of altitude, and Fig. 2D shows the corresponding inverted data and allows a comparison of the volume concentration profiles in two wavelength ranges.

These measurements at low latitudes agree with data (*6*) reported for the 25° to 35° latitude band in the stratosphere. At higher altitudes, where chemical oxidation processes become less efficient, another destruction process is needed to explain the mesospheric concentration decrease with altitude. Photodissociation of CH_4 in particular by solar Lyman-α radiation, plays a dominant role in modeling for higher altitudes.

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Waves in the OH Emissive Layer

Abstract. *An instrument designed to take pictures of infrared spatial structures from space was flown on Spacelab 1. An image intensifier was used to give enough sensitivity and images were recorded on photographic film. The instrument worked perfectly and 1771 pictures were obtained during the night on 27 orbits (one picture every 16 seconds). Image processing of the data will yield information about the extension of large-scale structures and the relation between medium-scale structures and gravity waves.*

It was recently discovered that the night sky exhibits patchy structures (*1–3*). This surprising result was obtained by taking pictures during dark moon periods with a fast lens and infrared photographic emulsion. Figure 1 is an example of such a display. Triangulation measurements give an altitude of 85 km for these structures, which are luminous by themselves. They look similar to noctilucent clouds, which are illuminated by the sun; however, the infrared structures can be seen at a solar depression angle of −45°, which excludes any diffusion of the light

Fig. 1. Photograph taken in the French Alps. Emulsion, high-speed infrared; lens focal length = 55 mm, *f*/1.2; exposure time, 10 minutes.