

Fig. 3. Band model predictions and observed spectra, runs 1125-3, -4, -5.

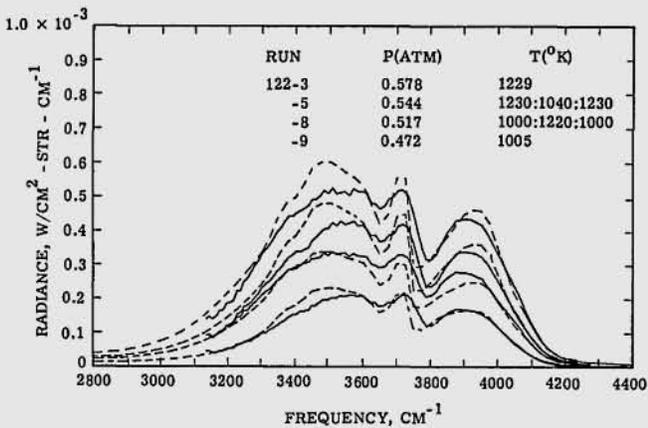


Fig. 4. Band model predictions and observed spectra, runs 1225-3, -5, -8, -9.

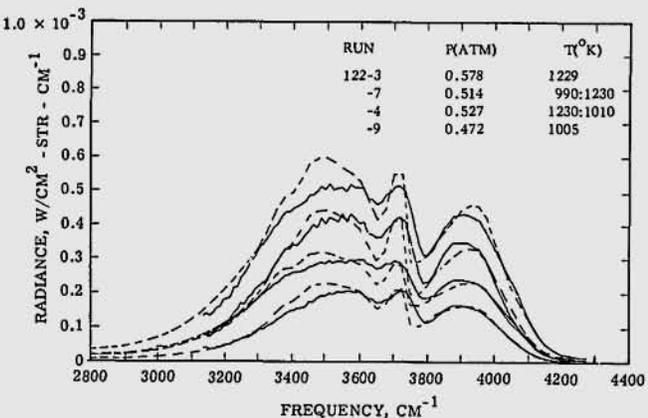


Fig. 5. Band model predictions and observed spectra, runs 1225-3, -4, -7, -9.

Ref. 2. The above equation, expressed in the approximate form

$$N_\nu = \beta_e \sum_{i=1}^n N_\nu^*(T_i) \exp[-\beta_e f(x_i)] [f(x_i) - f(x_{i-1})],$$

where

$$x_i = (PL/n\beta_e) \sum_{j=1}^i k(\nu, T_j) F(T_j)$$

was programmed for an IBM 7090 computer to provide values of N_ν at specified intervals for the nonisothermal emission from H_2O in the region 2800 cm^{-1} to 4400 cm^{-1} . The mean absorption

coefficients for H_2O tabulated by Ferriso, *et al.*³ were used. Values of β vs ν and T were calculated by $\beta = \beta_0(P/P_0)(1200/T)^{1/2}$ with data for $\beta_0 \equiv 2\pi\gamma_0/d$ obtained at 1200°K by Oppenheim and Goldman,⁴ see Ref. 3. An interpolation between the nearly weak and nearly strong-line approximations was made by use of the function $\eta = f(ax_L)(\pi/2ax_L)^{1/2}$, where $a = 0.05$ is an empirical constant.⁵ The calculations were made using an incremental length $L/n = 1 \text{ cm}$ and a spectral interval of 25 cm^{-1} .

Spectral radiances were so calculated for a 60-cm path in pure water vapor for the pressures and temperature profiles shown in Table I and Figs. 2(b)-6(b) of Ref. 1. The results are given in Figs. 1-5. The specified temperatures identify the type of profile: a single value signifies an approximately isothermal path; two values represent a more or less linear profile (e.g., 1220:1000 indicates hotter gas viewed through cooler); three values indicate a nearly triangular profile. The solid lines commencing at about 3150 cm^{-1} are the observed spectra which were shown in Figs. 2(a)-6(a) of Ref. 1; the dashed lines commencing at 2800 cm^{-1} are the predictions of the present band model. The agreement between the predicted and the observed spectra is generally better than that obtained with the strong-line models,¹ and is quite satisfactory in view of the probable error in the radiance measurements, the uncertainty in the bandmodel parameters (especially the line-overlap factor), and the differences in the degree of smoothing of the present data and those from which the bandmodel parameters were extracted.

Appreciation is expressed to N. F. Kent who programmed the bandmodel calculations. This work was supported by the Advanced Research Projects Agency, under a contract as a part of Project Defender.

References

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A Balloon-Borne Diffusing System for Infrared Radiation from 1μ to 5μ

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Received 17 April 1967.

Most measurements of solar radiation and atmospheric absorption by means of balloon-borne equipment end at about 30 km of altitude. The distribution of atmospheric constituents above that altitude is quite poorly known; yet it is of considerable importance in making any calculations on the chemistry of the mesosphere which begins at about 50 km. If altitudes higher than 30 km are desired, the payload that can be carried aloft by the balloon must be drastically reduced. In order to go higher, we decided to build a system which substituted a diffusing sphere for the conventional sun pointer, and a set of interference filters for the spectrometer. The system was designed to

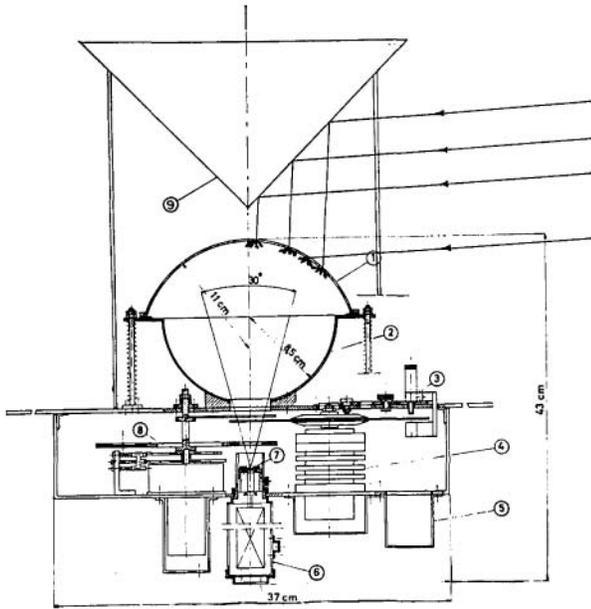


Fig. 1. Optical and mechanical components of the diffusing system: (1) diffusing dome, (2) reflecting hemisphere, (3) phasing system, (4) chopper and motor, (5) water drying container, (6) preamplifier, (7) detector, (8) filter wheel and motor, and (9) reflecting cone.

measure the absorption of the minor atmospheric constituents as the sun set and passed below the horizon.

A diagram is shown in Fig. 1. The light from the sun at near horizontal angles strikes the reflecting cone and is reflected down on the diffusing dome. This light plus the sunlight hitting the diffusing dome is then scattered into the detection system. The diffusing dome, made of calcium aluminate glass, was ground with 220 carborundum and had a useful transmission from 0.3–5.5 μ . Tests showed that the intensity of the light incident at horizontal angles and scattered into the detector is diminished by approximately a factor of 100 over light incident at normal angles. For this reason the reflecting cone made of polished sheet aluminum was added. It improved the signal-to-noise ratio by more than an order of magnitude. In addition it served to hide the balloon from direct view of the diffuser. A reflecting hemisphere of plexiglas, aluminized on the interior, was used to reflect light back to the diffusing surface, where it is scattered a second time.

The light was chopped at 400 c/s by a disk with eight slots and a synchronous 50 c/s chopping motor. The motor was driven by a power amplifier consuming 33 W, the frequency being regulated by a quartz oscillator and a divider circuit. The filter wheel had positions for six filters, and one revolution took 90 sec so that each filter stayed in place for 15 sec. The changing of the filters was accomplished by a simple cam and spring mechanism. The optical zero was obtained from an opaque sector on the filter wheel, which cut off the radiation above the chopper. The other five filters were narrow bandpass interference filters in the range from 2.5–4.3 μ and having a half width of about 0.10 μ .

The electrical signal from the detector was amplified by a preamplifier of gain 7200 and a phase sensitive synchronous amplifier rectifier. Care was taken to shield all the cables, batteries, motors, and electronic components. A small light bulb and phototransistor, that could be rotated through 45°, provided the reference signal for the phase sensitive amplifier. An automatic range switching system with variable gains of 3.1, 13.1, and 52.3 was included to increase the dynamic range of the FM telemetry system.

The gondola with the telemetry transmitter weighed 43 kg. A first launching to test the equipment was made in October 1966 at Air sur l'Adour, France. It was made with a medium sized 20- μ polyethylene balloon of the French type description 20P4 and of 38,000 m³ fully extended volume. It reached an altitude of about 37 km. Owing to a shift in the optical zero, the data from the different interference filters could not be quantitatively analyzed for the abundance of the atmospheric constituents.

For all the drawbacks inherent in a diffusing system, the apparatus worked remarkably well. The intensity problem for low solar angles was largely overcome by the reflecting cone. A signal-to-noise ratio of more than 100:1 was achieved with the filter at 3.65 μ (in an atmospheric window) and a bandpass of 0.3 c/s. However, a limitation of the system is the selfradiation of the diffusing dome and reflecting cone in the ir. This radiation is being chopped and therefore detected by the electronics. Thus at 4 μ and 300°K the selfradiation was calculated to be about one tenth of the solar intensity. At lower temperatures and lower wavelengths this ratio becomes, of course, quite small. The lowest temperature of the cone measured during the flight was -55°C at 12 km of height and the highest temperature of 36°C occurred about half an hour after reaching the ceiling of 37 km.

One can conclude that the system shows good promise for use with a spectrometer instead of the rather primitive interference filters. A planned 40-cm $f/6$ Fastie-Ebert spectrometer could be used at a resolution of 0.01 μ with a reduction of intensity at the detector of about 100. This factor could certainly be regained by cooling the detector, or changing to a more sensitive PbS detector for shorter wavelengths.

This work was supported in part by a NASA grant; it was done at the Belgian Institute for Space Aeronomy while the author was holder of a National Academy of Sciences-National Research Council Fellowship supported by the Air Force Office of Aerospace Research.

Multipass Twyman-Green Interferometer

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Received 23 February 1967.

The testing of optical homogeneity or flatness by means of a Twyman-Green interferometer is done by evaluating the interferogram with the formula¹ $(\Delta P/P) = (T/\lambda)$; T is the wavefront deformation which is related to (for instance) a test mirror by $T = 2t$, where t is the deviation of the surface from flatness; P is the spacing of the interference fringes, which in the ideal case is parallel and equally spaced; and ΔP is the change of fringe spacing or fringe position.

The sensitivity of such an interferometer to wavefront deformations T is given by $S = (\Delta P/T) = P/\lambda$, which is a dimensionless number in the order of magnitude of 10⁵. The sensitivity, however, is sometimes still too low to permit evaluation to an accuracy better than $\frac{1}{20} \lambda$, because the accuracy of determining T or t depends upon how exactly the fraction $\Delta P/P$ can be read.

A means of multiplying the sensitivity of a two-beam interferometer such as a customary Twyman-Green interferometer is shown schematically in Fig. 1. An additional beamsplitter B_2 is inserted into one arm of the interferometer with a slight wedge angle with respect to M_1 , the mirror under test. As the collimated light undergoes n reflections between B_2 and mirror M_1 , a surface deformation t on M_1 will show up as a wavefront deformation of $2nt$ in that beam which has been reflected back