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AIRBORNE 20-65 MICRON SPECTROPHOTOMETRY OF COMET HALLEY

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ABSTRACT

We report observations of Comet Halley with a grating spectrometer on board the Kuiper Airborne Observatory on four nights in December 1985 and April 1986. We obtained 20-65µm low-resolution (*R*=24-40) spectra of the nucleus with a 40 acrsec FWHM beam on 17 Dec. 1985, and on 15 and 17 Apr. 1986. On 20 Dec. 1985 we obtained only a 20-35µm spectrum. Most of the data have been discussed in a paper in press (Glaccum *et al*, 1987; see also Glaccum *et al*, 1986) where we dealt with the continuum. In that paper we fit models to the continuum that showed that more micron-size particles of grains similar to amorphous carbon were needed to fit the spectrum than were allowed by the Vega SP-2 mass distribution, or that a fraction of the grains had to be made out of a material (silicates, e.g.) whose absorption efficiency fell steeper than λ^{-1} for λ>20µm. We also presented spectra taken at several points on the coma on 15 Apr. which showed that the overall shape of the spectrum is the same in the coma. Tabulated values of the data and calibration curves are available from W. Glaccum. Here we discuss the spectral features.

The spectrum on 20 Dec. has an unresolved emission feature at 28.1±0.4µm, with a total flux of (6.3±3.1) $\times 10^{-14}$ Wm^{-2}. The uncertainty includes both the statistical noise and the uncertainty in atmospheric transmission. This is consistent with the 28.4µm feature seen by Herter *et al* on 14 Dec. 1985. We did not see the feature on the other nights. On all nights the spectrum can be fit by blackbodies with T=360-400K. On 15 April the spectrum has 4 broad ($\Delta\lambda \approx$4µm) emission features centered at 23.5, 28.0, 34.5, and 45µm which peak about 7% above the continuum. The first 3 features are present in the spectra on the other nights, but to a lesser degree of confidence. The broad 28µm feature may be absent on 2 of the flights. The peak wavelengths of these features correspond closely with maxima in Q_{ext} of small olivine particles (Koike *et al*, 1981). Olivine has been proposed as a candidate material to explain the double-peaked structure of the 10µm feature (Campins and Ryan, 1987; Bregman *et al*, 1987).

References

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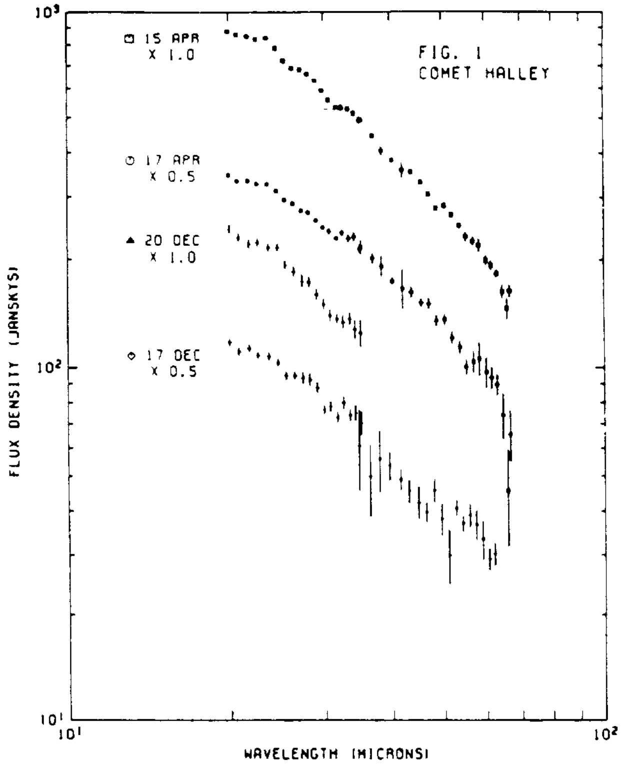

Fig. 1. The spectrum of Comet Halley on 4 nights with a 40 arcsec beam centered on the nucleu: All spectra are calibrated to Mars using the Wright model (Wright, 1976; S.F. Odenwald, 1983 private comm.); the April flights are calibrated directly, and for the December flights the calibration is transferred through α Ori. A new model for Mars by P. Christensen and B. Jakowsky (priv. comm.) would increase each spectrum uniformly by 10%. The spectra are corrected for telluric wat vapor absorption by adjusting the amount of water vapor until the water lines disappear. Hence, th 28μm feature does not appear in the 20 Dec. spectrum. The dip at 65μm and the jump at 50μm are poorly corrected water lines. The structure in the 17 Dec. spectrum at $\lambda>30\mu$m is spurious an appears in other objects to a lesser degree. The spectra for 17 Apr. and 17 Dec. are slightly different than those shown in the two Giaccum et al references. The overlap of the 2 grating settings occurs at 35μm. The agreement on all objects was excellent in April and good in Decemb

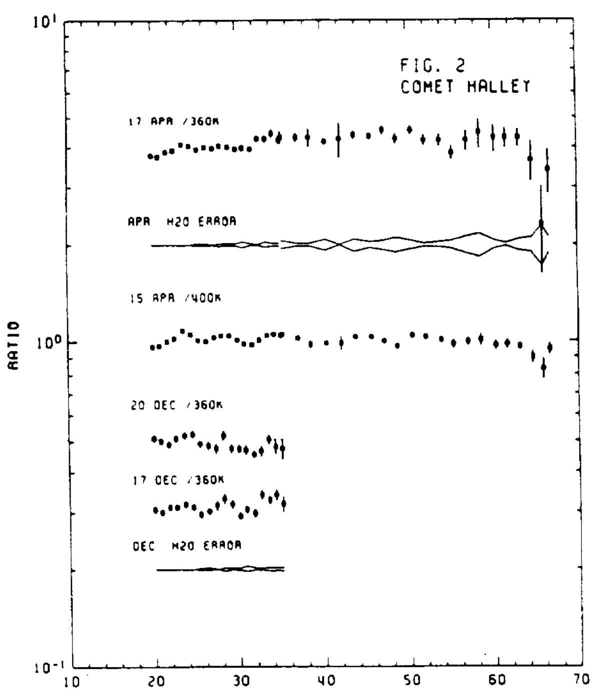

Fig. 2. Spectra of Comet Halley relative to blackbodies. To increase the contrast we have divided each spectrum by a blackbody which fits the overall 20-65μm spectrum. Also shown are the effects on the spectra by a change of ±20% in the ratio of boresight water vapor on the comet and calibration legs. The data for the April flights is the same as in Fig. 1. For the December flights we have used a different calibration procedure. The comet data are calibrated to α Ori assuming it has a smooth spectrum and using values for water vapor from the on-board radiometers. The 28μm feature appears as a 9.5%±3.8% excess in one channel; to remove it by adjusting water vapor requires a change by a factor of 3 in the ratio of boresight water vapor (as measured by the on-board radiometers) on the comet leg and the α Ori leg. Such a large error in the values obtained by the water vapor radiometers is unlikely, as this ratio has a standard error of 25% for the 5 other objects on the flight, if we assume that we can determine the ratio to ±10% on those objects by removing the water lines. The 25% standard error is typical. We cannot rule out the possibility of the feature being due to a change in sensitivity of that detector during the flight, but such changes are rare and have never been seen in that channel, and nothing was unusual about any other objects on that flight either before or after the comet.

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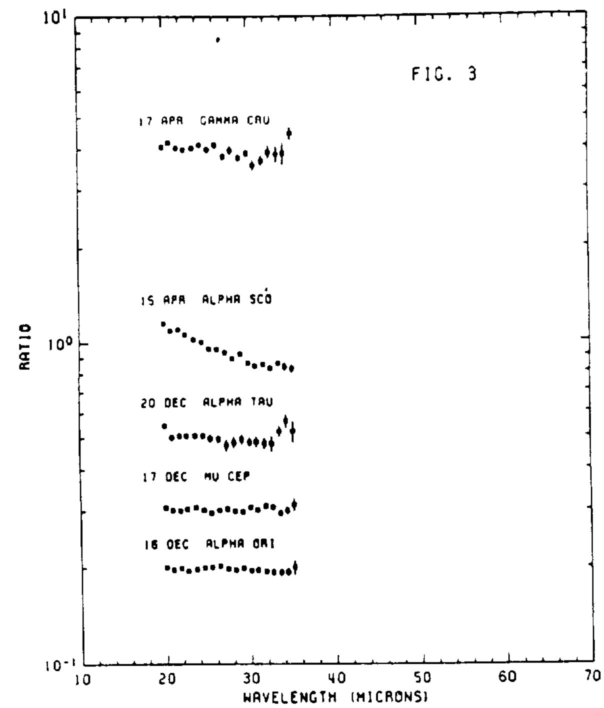

Fig. 3. Spectra of 5 representative stars relative to blackbodies (Glaccum, Ph.D. thesis, in preparation). To give the reader an indication of the noise in excess of "statistical" noise, we show representative stars from each flight, reduced in the same way as the comet (Fig. 2), and plotted to the same scale. Included is the spectrum of α Ori on 16 Dec., the night which Mars was observed. This has been divided by $B_\lambda(T=3500K) \cdot \lambda^{-0.155}$ so that the "smooth" spectrum used to reduce the December data in Figs. 2 and 3 is a straight line at y=0.2. The spectra of other stars are divided by a 3500K blackbody. The emission from γ Cru and α Tau is from their photospheres and should be featureless. We also expect α Sco and μ Cep to be featureless. The structure in the spectrum of γ Cru is due to a correction for a change of instrumental sensitivity during the flight and represents a worst-case example; the corresponding corrections for the comet are much smaller (<2%).