Figure 4—Received frequency of the Giotto carrier plotted as a function of time near encounter. Frequency and time origins are arbitrary and the pre-encounter and post-encounter Doppler lines (slope \(-0.6\, \text{HZ s}^{-1}\)) were fitted to data points before and after encounter (most points are outside the range of the expanded plot shown above).

the preliminary estimate is valuable because a mass fluence in the range 0.1 - \(1G\) is near the upper limit set in pre-encounter predictions (ESA 1984), confirming a correspondingly high particle density in the coma and favouring a cometary environment model such as the one given by Devine (1981). Detailed analysis and correlation of the GRE data from Parkes and Tidbinbilla will give more accurate results which may be useful in normalizing the output from on-board dust detectors. A comparison of GRE Doppler results with those obtained using Giotto ranging data is also planned.

The Parkes AGC data provide a unique insight into the behaviour of Giotto around the time of encounter. Phase-locked receivers at Tidbinbilla utilized a much longer loop time constant, obscuring much of the detail visible in the Parkes recording. Analysis of the Parkes AGC information by spacecraft system specialists will give information about the performance of on-board attitude control systems.

Finally, it is worth noting that the GRE was the only experiment to function virtually uninterrupted throughout the encounter. Valid radio science data were recorded continuously at both Parkes and Tidbinbilla, except for the 20 s interval during which the receivers at both stations lost lock. In contrast, all on-board experiments suffered at least some data loss for 20 min after encounter.

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Observations of 18 cm OH Emission and Absorption from Halley’s Comet

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Abstract: The 1665 and 1667 MHz OH intensity towards Halley’s comet has been monitored during the period October 1985 to April 1986. The flux density variation during the course of the apparition roughly follows the predictions of Schloerb and Gerard (1985), although we find a systematically lower flux than they predicted. The relative intensities of these lines are approximately in the ratio expected for thermodynamic equilibrium.

Introduction
Cometary OH was first detected at radio wavelengths in Comet Kohoutek (1973) by Turner (1974) and independently by Biraud et al. (1974). Since then it has been reported in at least seven other comets (e.g. Snyder 1982; Norris et al. 1985).

Observations of the OH lines can give information about the size and density of the coma, gas outflow velocities, and the populations of the various OH energy levels. In this paper we present measurements of the variation of OH intensity and the relative strength of the two main lines during the course of the 1986 apparition of Halley’s comet.

If current ideas (e.g. Schloerb and Gerard 1985) on the production of OH lines in comets are correct, the intensity of the OH lines depends on three main factors.

1. The OH column density, which depends on the production rate of parent and daughter molecules.
2. The distribution of energy levels, which depends on pumping by UV radiation from the Sun. The details of this pumping are determined by the Doppler-shifted UV
spectrum seen by the comet, and thus by its heliocentric radial velocity. This effect, akin to the Swings effect (Swings 1943), is profound; at some heliocentric velocities the comet appears in emission and at others in absorption (Figures 1, 3).

3. The background continuum radiation, which provides the incident photons for absorption or for stimulating maser emission.

Results
Our observed flux densities are shown in Figure 2 as crosses. We have corrected these for resolution effects by using the prescription given by Schloerb and Gerard (1985: Figure 2), and by assuming a constant parent molecular scale length of \(10^5\) km and a circular Gaussian beamwidth of 12.5 arcmin. Thus the flux densities in Figure 2 are expressed in terms of the flux density that would be observed by a telescope for which the source was unresolved.

Also shown in Figure 2 are the flux densities predicted by the model of Schloerb and Gerard (1985). Between October 1985 and May 1986 the coma is well-developed and large OH intensities are predicted. Prior to February 1986 the solar UV radiation is blue-shifted relative to the comet, and produces a population inversion and OH maser emission. After early March 1986 the red-shifted solar UV radiation produces a corresponding OH absorption line. During occultations of strong continuum sources, such as the plane of the Galaxy and Centaurus A, intense emission or absorption is expected, depending on the excitation conditions.

Comparison of Observations with Predictions
The observed and predicted fluxes agree in sign but the observed fluxes are systematically lower than those predicted. This discrepancy may be attributed mainly to the uncertainties inherent in Schloerb and Gerard’s (1985) model.
1. The model uses a parent-molecule production rate based on measurements of previous comets, but comets are known to vary greatly and randomly, both one to another and with time.

2. The model assumes that the distribution of the parent molecules is spherically symmetrical with a scale length which is independent of the heliocentric distance of the comet. This is unlikely to be true.

3. The model assumes that all OH molecules are derived from parent water molecules, whereas the preliminary results from the Vega spacecraft (Krasnopolsky et al. 1986) indicate an OH molecular production rate which exceeds the water molecule production rate. This makes it likely that organic parent molecules constitute an additional source of OH molecules.

Smaller errors may arise from our assumption of a Gaussian circular beam shape. We are continuing to examine the effect of all these factors on the derived flux densities.

**Line Intensity Ratios**

If UV pumping, which does not distinguish between the hyperfine transitions, is the dominant process, the ratio of line intensities in the 1665 and 1667 MHz lines is expected to be close to the thermodynamic equilibrium value of 1.8. Figure 3 shows wideband (5 MHz) spectra for two periods: one when the comet appeared in emission and one in absorption. In both spectra the 1667/1665 MHz intensity ratio is 1.8 to within the error of measurement. These measurements are in agreement with the value expected for thermodynamic equilibrium and therefore support of UV pumping model, as assumed by the model of Schloerb and Gerard (1985).

During the passage of the comet across the Galaxy and Centaurus A in April 1986 an attempt was made to map the OH distribution in the coma with 12.5 arcmin resolution. The strong absorption lines present also allowed high signal-to-noise ratio spectra to be obtained on time scales of a few minutes. These latter observations will be discussed separately (Norris et al., in preparation).

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**Meteors**

**Frequency Dependence of Radar Meteor Echo Rates**

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Abstract: Meteor rates have been measured with a large HF Radar at a number of frequencies. At the top end of the HF band our results match those of Greenhow (1963). However at lower frequencies we find high echo rates which indicate that past observations measured only a few percent of the total meteor flux incident on the Earth’s atmosphere. This explains the ‘missing mass’ discrepancy observed when radar results are compared with satellite or visual data. Accounting for this missing mass results in a four-fold increase in the calculated