

### Submillimetre Wave Observations at an Altitude of 40,000 ft.

A PRELIMINARY experiment has been carried out to investigate the feasibility of making submillimetre wave measurements from a jet aircraft flying in the stratosphere. The value of such aircraft as observation platforms is that very low values of water vapour content in the line of sight can be obtained and water vapour is the dominant atmospheric absorber at submillimetre wavelengths. In this sense the experiments can be regarded to continue those made at high altitude observatories<sup>1,2</sup>, but to improve on them greatly because it was possible to determine lower total water values.

The aircraft used was the N.A.S.A. Convair 990 'Galileo' which was equipped for observing eclipses. A polypropylene window was specially installed in the fuselage and this enabled observations to be made of the sky or of the Sun at an angle to the zenith of 65°. The face aperture of the window was about 25 cm × 25 cm. Spectroscopic measurements were made by the Fourier transform method using an N.P.L. modular interferometer (Fig. 1) and a Golay cell detector. The spectral range investigated was about 10 cm<sup>-1</sup> to 70 cm<sup>-1</sup> (1 mm to 130 μ).

The main result obtained from a very limited set of observations is a spectrum of the transmission of the atmosphere in the range 15 cm<sup>-1</sup> to 65 cm<sup>-1</sup> obtained by recording interferograms of the exchange of radiation between the hot Golay cell detector (temperature 310° K–330° K) and the cold sky background (temperature about 220° K). This is modified by water vapour absorption lines as shown in Fig. 2, where the theoretical positions and strengths of H<sub>2</sub><sup>16</sup>O lines are added. It will be seen that there is a good correlation with the theoretical prediction. In particular it is of interest to verify the existence of the low absorption region at about 50 cm<sup>-1</sup> because this "window" may be important when further sub-millimetre wave observations are made. Our present observations were made at a height of 40,000 ft. when flying at a latitude of 46° N. The total water content above the aircraft under these conditions was of the order of 20 μ of precipitable water. In addition, we verified that much larger signals are obtainable from the Sun (the expectation is that they would be about twenty times greater and of course of opposite sign) than from the sky, but our arrangements for following the Sun were too primitive for useful spectra to be recorded.

There is one notable anomaly in the spectrum shown in that an absorption feature occurs at 30.5 cm<sup>-1</sup> which is much stronger than would be expected from the known water line (3<sub>2</sub>→4<sub>0</sub>) at this frequency. Although the limited number of observations which we made in this experiment makes it inadvisable to attach too much weight to this result, we think that it is qualitatively correct and should certainly be investigated further.

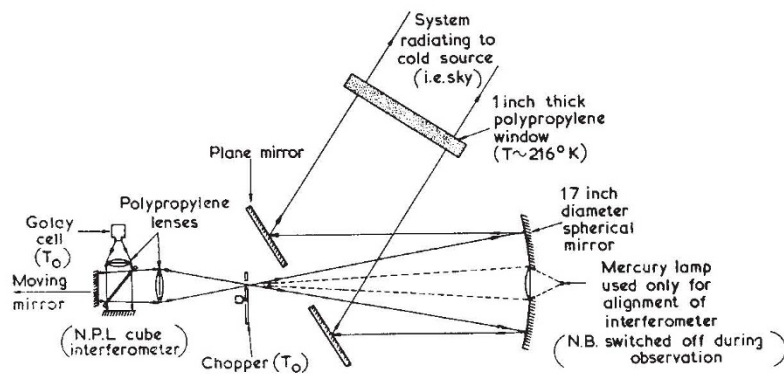


Fig. 1. Schematic diagram of the experimental arrangement of the telescope and the N.P.L. modular interferometer.

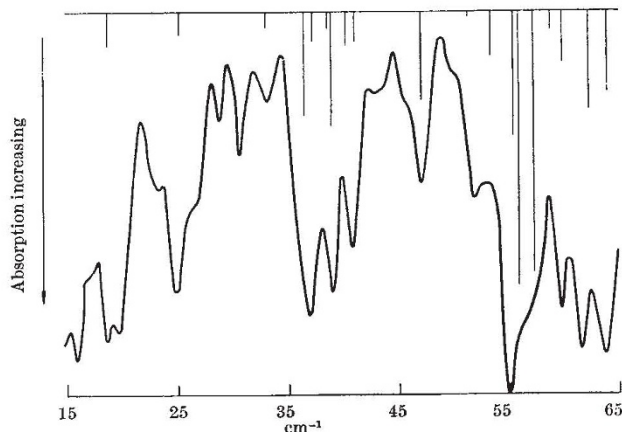


Fig. 2. Observed spectrum of the sky at 40,000 ft. showing atmospheric "windows" and compared with theoretical water vapour spectrum. (Resolution, 1.33 cm<sup>-1</sup>; precipitable water, 20 μ).

These observations, which so far as we know are the first to be made in the range 30 cm<sup>-1</sup> to 60 cm<sup>-1</sup>, show that high flying aircraft offer a good means of making sub-millimetre observations and further work is planned.

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<sup>1</sup> Gebbie, H. A., *Phys. Rev.*, **109**, 1174 (1957).

<sup>2</sup> Farmer, C. B., and Key, P. J., *App. Opt.*, **4**, 1051 (1965).

### Evidence for Organic Complexed Copper in Sea Water

COPPER has probably been the most extensively investigated trace metal in sea water, yet little is known of the contributing chemical forms. Atkins<sup>1</sup> used sodium diethyldithiocarbamate to complex the ionic or more easily chelated copper and more recent investigators have continued to use this method<sup>2</sup> or have substituted dithizone or some other chelating agent. The complexed copper may later be extracted into a suitable organic solvent such as chloroform or carbon tetrachloride and determined colorimetrically. The use of these procedures has meant that the majority of results reported in the literature refer only to the readily chelated, divalent fraction of copper.

A few attempts have been made to characterize the chemical components contributing to the copper content of sea water. Love-ridge *et al.*<sup>2</sup> found about 0.3 μg/l. of particulate copper in two stations in the English Channel and Buglio *et al.*<sup>3</sup> found 15 μg/l. of ultrafilterable (10 mμ) but non-dialysable copper in a sample from Texas Bay. Corcoran and Alexander<sup>4</sup> have presented evidence for copper in the organic form in waters of the