Observations of Far Infrared Atmospheric Windows at 44 cm\(^{-1}\) and 50 cm\(^{-1}\) from Pikes Peak

Absorption by atmospheric water vapour seriously restricts astronomical observations from the ground in the far infrared region of the spectrum. Between 300 cm\(^{-1}\) and 18 cm\(^{-1}\), the atmosphere is nearly opaque from the ground, except from high mountain sites where weak windows appear at 29 and 22 cm\(^{-1}\) (350 and 450 \(\mu\)m). These windows were first observed by Gebbie\(^1\); they have since been used by several investigators for mountain top astronomical measurements\(^2\)\textsuperscript{-10}. To our knowledge, there have been no astronomical observations from the ground in the region between 300 cm\(^{-1}\) and the 29 cm\(^{-1}\) window. In this frequency decade of the electromagnetic spectrum astronomy has required the use of aircraft\(^1\textsuperscript{11\textsuperscript{-16}}\) and balloons\(^1\textsuperscript{7\textsuperscript{-24}}\) as observing platforms.

During April 1971, we operated far infrared and meteorological equipment on the summit of Pikes Peak, Colorado (latitude 38° 50' N; longitude 105° 03' W; altitude, 4,301 m) as part of an infrared site survey. The infrared system included a photoelectrically guided telescope of 20 cm aperture, scanning Michelson interferometer, helium-cooled germanium bolometer, and small digital computer. The meteorological equipment included instruments for measuring integrated water vapour along the line of sight to the Sun, sky brightness and seeing, as well as temperature, wind and cloud cover. We observed the Sun on fourteen clear mornings and the Moon on five nights. Generally, the total quantity of precipitable water in the line of sight was less than 2 mm (ppt. mm) during observations.

The meteorological conditions on April 13 were unusual. A stratus layer at 3,000 m was capped by temperature inversions 500 m thick at 3,300 and 4,300 m. A pressure ridge overhead provided a subsiding airmass with very dry air. Convection did not lift low lying moisture above the summit until 1200 LT and even then the dry air persisted intermittently until 1515 LT. The near infrared water meter showed 0.32 ppt. mm in the zenith at 1500 LT, but this increased to nearly 2.0 ppt.

mm at 1600. In the far infrared solar spectra, which were taken before noon, two previously unreported atmospheric windows were clearly visible, at 44 and 50 cm\(^{-1}\) (225 and 200).

In Fig. 1 we show a portion of one solar spectrum with resolution 0.065 cm\(^{-1}\) taken through 1.18 airmass at 1111 standard time (1811 UT) on April 13. The two new windows extend from 42 to 46 cm\(^{-1}\) and from 48 to 52 cm\(^{-1}\), separated by the strong 5.3-5.1 water vapour line at 47.05 cm\(^{-1}\). The windows are crossed by water vapour lines at 42.62, 43.24, 44.11, and 51.44 cm\(^{-1}\) and the forbidden magnetic dipole lines of oxygen at 48.93 and 50.87 cm\(^{-1}\), as well as numerous weak lines of ozone. From an analysis of water lines in the 15 to 35 cm\(^{-1}\) region of the same spectrum, we compute the total water quantity to be 250 ± 50 ppt. \(\mu\)m in the line of sight, or 210 ppt. \(\mu\)m overhead. The average mass mixing ratio above the peak was 37 × 10\(^{-6}\).

For comparison we have computed the transmission of a model atmosphere containing 200 ppt. \(\mu\)m of water in the line of sight, 0.275 cm atm of ozone in the zenith, and a 0.2314 mass fraction of oxygen. The water was distributed in five layers in the proportions given by Gutnick\(^2\). The ozone was in a layer centred at 25 km. The data on the water lines come from the tabulation of Yunker and Querfeld\(^2\). For ozone we used the data of Gora\(^2\) and for oxygen, that of Gebbie, Burroughs, and Bird\(^2\), corrected to the temperature of the US Standard Atmosphere. The portion of the resulting spectrum, convolved with the interferometer instrument function, corresponding to the new windows is shown in Fig. 2.

The agreement between the spectra in Figs 1 and 2 is good, especially the strength of both weak and strong water lines and the oxygen lines at 48.93 and 50.87 cm\(^{-1}\). The noise is much too great for much analysis of the ozone lines. The reduced signal level in the 50 cm\(^{-1}\) window compared with the 44 cm\(^{-1}\) window in Fig. 1 results from the decrease of instrumental efficiency caused by the metal mesh beam splitter and by the roll off of the numerical filter used in the analysis. The conclusion that the average transmission in each window is between 25 and 30\% is based on the synthetic spectrum which matches the observed spectrum not only in these windows, but also near 29 cm\(^{-1}\) where the transmission is about 75\%. This conclusion is consistent both with the observed signals and the decline in instrument efficiency at higher frequencies.

A preliminary report of the site analysis of Pikes Peak has been made\(^2\). Detailed site analysis will be published elsewhere, as well as the far infrared observations.

Fig. 1 Portion of observed solar spectrum between 40 and 54 cm\(^{-1}\), Pikes Peak, April 13, 1971. Intensity in arbitrary units. Lower intensity in the 50 cm\(^{-1}\) window results from decreasing metal mesh beam splitter efficiency and roll off of the numerical data filter.

Fig. 2 Computed transmission of atmosphere above Pikes Peak, including absorption by oxygen, ozone and 200 ppt. \(\mu\)m of water, convolved with instrument function of 0.065 cm\(^{-1}\) width.
We suggest that it is possible to make far infrared astronomical observations at wavelengths of 200 and 225 μm from high mountain top observatories under unusual wintertime meteorological conditions. How often such conditions occur at given sites is as yet conjectural.

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Possible Cryptic Suture in South-west Newfoundland

The concept of an important fault, the Cabot Fault, cutting across western Newfoundland was proposed by Wilson, who interpreted it as a great sinistral fault and correlated it with the Great Glen Fault system in Scotland. There is, however, a second large fault in south-west Newfoundland, the Cape Ray Fault, the importance of which has previously been unrecognized. This fault separates two entirely different pre-Ordovician gneissic terrains which, when traced north-eastwards from Port aux Basques (Fig. 1) form the eastern and western margins of the Newfoundland Central Mobile Belt. This belt contains Lower Ordovician rocks in its central part which are interpreted as remnants of an old ocean floor, the proto-Atlantic (1-5). The Cape Ray Fault thus effectively cuts out this ocean toward the south and juxtaposes its eastern and western margins. It may therefore represent a cryptic suture along which complete closure of the proto-Atlantic took place.

Three major terrains are recognized in south-west Newfoundland, the Cape Ray Complex, the Port aux Basques Complex and the Windsor Point Group (Fig. 1). The Cape Ray Complex is bounded on the west by the Cabot Fault and on the east by the Cape Ray Fault, and consists essentially of a leukogineous gneiss, the Long Range Gneiss, intruded by granitic and mafic phases. The gneiss is a coarse-grained, intensely retrogressed, leukogneiss with at least two tectonic fabrics. Stretched, blue quartz porphyroblasts are character-