involved in the phase transition the energy, E, which is released, is given by:

$$E = 5 \times 10^{13}\ \mathrm{g} \times 24\ \mathrm{calorie\ g^{-1}}$$
$$= 10^{15}\ \mathrm{calorie}$$

This can generate water vapour of mass, M:

$$M = E/H = 10^{15}\ \mathrm{calorie}/650\ \mathrm{calorie\ g^{-1}}$$
$$= 1.5 \times 10^{12}\ \mathrm{g}$$

where H is the heat of sublimation. This means that 3% of the generated particulate matter is sublimated. This gas must certainly expand into the vacuum of space at a few times the velocity of sound, carrying with it, at least to an order of magnitude, a comparable mass of dust. This mass is consistent with observed values for typical comet outbursts[8].

A large fraction of the fractured material remains on the surface. This effectively creates an insulating layer with a high albedo which tends to prevent further outbursts for some time.

This picture of comet outbursts can be subjected to many refinements, such as variations of comet sizes, or of rotation rates and inclinations, impurities and inhomogeneities in the ice, and orbital parameters. The general features of this theory are, however, consistent with observations and in our opinion provide for a more plausible source of energy than has been previously suggested. Those suggestions have included the vaporisation of pockets of methane and/or carbon dioxide[8], explosive radical reactions[12], and collisions with interplanetary boulders.

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Ratio of the temperatures of the quiet Sun and the centre of the new moon at λ = 1.3 mm

As radio wave spectral line observations are made at ever shorter wavelengths, the need for precise calibration increases. This is because, as a larger portion of the frequency spectrum becomes available for observation, an increasing number of multiple molecular transitions will be detected. To obtain reliable excitation parameters from these detections they must be calibrated accurately at each frequency. Linsky[1] has proposed the Moon as a radiometric standard for observations of extended sources in the infrared, millimetre and microwave portions of the spectrum. We therefore measured the ratio of the quiet Sun temperature to that of the centre of the new Moon at 231 GHz (λ = 1.3 mm).

The 36-foot telescope of the National Radio Astronomy Observatory (NRAO) was used for the measurements, on June 30, 1973. At λ = 1.3 mm, using a 1.21λ by 1.77λ feed horn, the telescope has a beam size of 44″ × 51″ of arc as measured on Jupiter. A single ended mixer receiver was used that incorporated a Schottky-barrier diode as the nonlinear element[2]. The noise temperature of the double-sideband receiver was 6,000 K, and the intermediate frequency bandwidth was 60 MHz, giving a ΔT r.m.s. of ~ 1.5 K with a time constant of 0.25 s.

At this frequency, antenna calibration is rather uncertain and atmospheric attenuation can be quite high, and so it was decided to carry out the observations when the Sun and Moon were close together in the sky. This allowed a comparison of brightness temperatures without any first order dependence on either the antenna or the atmospheric calibration. June 30, 1973 was the date of a total solar eclipse and during our measurements the centres of the Sun and Moon were separated by 6° 45′ in the sky: the elevation of the Sun was 41.7° and that of the Moon was 47.7°.

The absolute temperature scale of the receiver was calibrated by placing absorbers, alternately at room temperature and liquid nitrogen temperature, in front of the feed of the antenna. Sky dipping data gave an average value of ~ 1.2 db attenuation/atmosphere (clear weather; 27° C; 35% relative humidity) which implied a differential attenuation of 0.18 db between the central solar and lunar positions. The Sun was observed through the dome of the telescope which had been previously measured (using the Moon) to have an attenuation of 2.87 db.

Antenna temperatures referred to an elevation angle of 41.7°, which, if corrected for dome and differential atmospheric attenuation would be 2,481.5 K and 53.2 K for the centres of the Sun and Moon respectively; a value of 46.6 for their ratio. Assuming that the temperature of the quiet Sun is 5,800 K at λ = 1.3 mm[3], a value of 124.5 K is derived for the central lunar temperature at new Moon.

An examination of Hα and K spectroheliograms of the Sun taken on the day of our observations by the McMath-Hulbert Observatory, showed that except for a small flare close to the eastern limb of the Sun, the solar disk, particularly the central region where our observations were taken, was free from any major disturbance. This was confirmed by drift scans of the Sun during the observations. Thus, we are confident that the ratio quoted does refer to the quiet Sun.

Because of our method of observation, the value we have derived for the ratio of the quiet Sun to that of the new Moon is relatively insensitive to any errors in the absolute calibrations of the atmospheric attenuation, the antenna or the receiver. The value mainly depends on the linearity of the detector and the noise on the signal. Thus, we calculate that the error on the derived ratio—46.6—is ± 0.4.

Bastin *et al.*[3] quote the error on their solar measurement as ± 400 K. Consequently, the value we have derived for the central lunar temperature at new Moon—124.5 K—has an uncertainty of ± 8.6 K.

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