Mauna Kea telescope debate

SIR — Sir Bernard Lovell (*Nature* 21 April, p.650) has given a valuable resume of the history of the UK millimetre wave telescope but he did not mention the site. From his account I learned with increased concern that the telescope is now being designed for sub-millimetre wavelength and this was confirmed by an announcement (*Nature* 16 June, p.564) that construction had begun. The telescope is to have a 15-m diameter disk accurate to the Rayleigh limit for a wavelength of 0.3mm. This is indeed a courageous enterprise and it is not surprising that the cost is to be borne by the UK Science and Engineering Research Council (SERC).

Since the telescope is now being made for sub-millimetre wavelengths, the driest site available must be used, so my suggestion[1] that a medium altitude desert site might be considered as an alternative could now be invalid. The choice of Mauna Kea could, therefore, be justified if it were proven that a telescope located there could be used with reasonable efficiency to make observations at 0.3mm. This I doubt.

The possible impediments are these. The acceptable amount of precipitable water is much lower at this wavelength than for operation at 1 mm, which may severely limit the amount of usable telescope time. In addition, an anomalous absorption component must also be absent or small. The possibility of such absorption has been shown by the only two published measurements[2,3] of atmospheric transmission at Mauna Kea. Finally the fluctuations in transmission, which there is good reason to believe are associated with anomalous absorption, must not be such as to swamp receiver noise. These are stringent conditions and the pointers from published work suggest that they are not often realized.

I have examined most of the references given by Dr Richard Hills (*Nature* 21 April, p.650), in support of his contention that the Mauna Kea site is adequate and my interpretation of these is different from his. The conditions in which observation at the shorter wavelengths can be made at all are the exception rather than the rule. This is supported by the experience at Mauna Kea of some US workers[4] who say:

> Even from a high dry site such as Mauna Kea the atmospheric transmission at 434 xm is highly variable and acceptable for astronomical observations for only a small fraction of the time.

This work was cited by Dr Hills in support of his views. I submit that he is not justified on this basis, and indeed from other references he has quoted, in rejecting the results of ref. 3 and, by implication, those of ref. 2. These two groups of researchers were quite independent and their results are in substantial agreement.

My doubts about Mauna Kea have additional support from a recent *Nature* publication[5] which showed an obvious gap in an interesting spectrum measured at Mauna Kea; the authors remarked:

> Although the conditions were stable during the run the atmospheric water vapour was insufficiently low to allow 350 μm observations to be productive.

The question of the adequacy of the site could, however, have been completely resolved by the results of a sufficiently sustained and thorough investigation of the behaviour of atmospheric transmission for wavelengths extending down to one-third of a millimetre. If this has already been made, there can surely be no reason for withholding its results from immediate publication. If it has not, then SERC is open to the charge of irresponsibly starting to construct an expensive telescope on a site where its high precision may be effective so rarely that it will not justify its construction and maintenance cost.

The pressing need for improved justification or complete reconsideration of this project is evident from the high real cost. There is, in addition to the capital cost of £7 million, a sum to be added for maintenance throughout the telescope's effective lifetime, which could amount to about £15 million. The general issue is the justification for another £20-odd million investment in astronomy, 80 per cent of which is funded by the UK taxpayer, at a time when SERC is unable to support alpha-plus proposals in small science. The doubt is aggravated by the suspicion that in this case the project may be technically on a much less sure foundation than the various radio, infrared, optical, ultraviolet and X-ray region projects which the taxpayer has already supported handsomely. British astronomers have had a generous share of national resources. The time has come for other enterprises to have support.

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1. Gebbie, H.A., Llewellyn-Jones, D.T. & Knight, R.J. *Nature* **299**, 280 (1982).
2. Nolt, I. *et al. J atmos. Sci.* **28**, 238 (1971).
3. Moffat, P.H., Bohlander, R.A., Macrae, W.R. & Gebbie, H.A. *Nature* **211**, 580 (1981).
4. Fetterman, H.R. *et al. Science* **211**, 580 (1981).
5. Gear, W.K. *et al. Nature* **303**, 46-47 (1983).

RICHARD HILLS REPLIES:

SIR — Dr Gebbie's letter is founded on the premise that the main purpose of the UK/Netherlands telescope is to observe in the "windows" at 0.35 and 0.45 mm. This is not so. The approved specification is that it shall be "usable over the range 13 to 0.3 mm, but optimized for the range 4 to 0.8 mm". The unique combination of large collecting area, high precision and high altitude site will enable the new instrument to undertake an enormous amount of exciting astronomy in the 4 to 0.8 mm waveband.

There is ample evidence to show that atmospheric absorption will not be a serious hindrance here. The evidence comes from published observations, of which the references given in my previous letter (*Nature* 21 April) are only a sample, from measurements made available directly to the project by both astronomers and atmospheric physicists, and from several site surveys. It is clear from these that the strong absorption reported by Dr Gebbie's group is not normally present.

The virtually unexplored waveband between 0.8 and 0.3 mm offers a tremendously challenging further opportunity. Naturally we are well aware of the difficulties caused by the atmosphere at these wavelengths, although these are somewhat mitigated by the steeply rising spectra of many of the sources to be investigated. The fact is that such observations are already being made with the existing telescopes on Mauna Kea.

The paper by Fetterman *et al.* is a fine example of what can be done: as well as spelling out the problems in the passage quoted by Dr Gebbie, they report important new findings on the high velocity gas flow in Orion. The quotation from Gear *et al.* simply confirms that the 0.35 mm "window" is not always open. Our estimate is that something like 2,000 hours a year will be suitable for observing at these shortest wavelengths, and the plans for the 15-m telescope are designed to make maximum use of these opportunities. Rapid beam switching will be used to subtract atmospheric emission and up to four receivers can be installed simultaneously so that the observing frequencies can be changed quickly in response to changing conditions.

It will be possible to make observations under remote control from sea level and even direct from Europe. This will cut costs and facilitate flexible scheduling of the telescope so that the best atmospheric conditions can be used for the most critical observations. It is in order to plan this in more detail that continuous monitoring of the atmosphere is now being carried out and, when a reasonable statistical base has been obtained, the results will be published.

Finding the right balance of expenditure between world-class research facilities such as the millimetre-wave telescope and innovative "small" science projects is an important problem, but it is quite separate from the question of atmospheric transmission on Mauna Kea. Dr Gebbie is entitled to his opinions, but it seems to me that these issues need deeper analysis than he has given here.

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