INTERFERENCE PROBLEMS AND RADIO ASTRONOMY IN THE UK

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ABSTRACT The radio regulations often require frequency bands to be shared between radio astronomy and services which transmit. This poses severe problems in a small island, given the sensitivity of radio astronomy receivers. The survival of radio astronomy in these circumstances depends on wide awareness of the problems. Some of the current sharing problems in the UK are discussed.

I would like to discuss some of the interference problems affecting radio astronomy in the UK. The UK Table of Radio Frequency Allocations lists 26 radio astronomy bands in the frequency range 38 MHz-49 GHz. There are 8 primary bands shared with passive users, 6 primary bands shared with active users, and 12 secondary bands shared with active users. Although Britain has a well-regulated system, and the national authority (the Department of Trade and Industry) is sympathetic, there are immense difficulties in sharing bands with transmitters in a small country. Radio astronomers in Britain and in other European countries face problems which could one day affect all ground-based radio astronomy (problems which reflect basic flaws in the present radio regulations).

The criteria necessary to protect radio astronomical observations are set out in CCIR Report 224. These are very general criteria based on bandwidth and integration time. The interfering signal is assumed to enter the far sidelobes of the antenna at 0 dB gain. Thus the dish size does not affect the calculation. The CCIR criteria are excellent criteria which would protect all types of radio astronomical measurement. Unfortunately they are not legally binding, and in practice they are virtually impossible to achieve in the UK, particularly at low frequencies.

It is important that we understand the technical difficulties of meeting the CCIR criteria. Fig. 1 shows the electromagnetic environment at Jodrell Bank in the frequency band 300-500 MHz (Holmes and Woodall 1987). Hidden among the forest of man-made signals are two radio astronomical bands. One at 326-328 MHz is used for VLBI and has a secondary allocation in Britain. The other is the primary shared band 406-410 MHz which is intensively used for MERLIN and pulsar observations. The CCIR level for harmful interference is -185 dBm in the units of this diagram. That is ~100 dB below the typical signal level at adjacent frequencies! The technical problems of protecting the radio astronomy

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bands to this level are immense, even for passive bands. Radio astronomy receivers have many stages of filtering distributed throughout the system to provide the necessary out-of-band rejection, and to minimize intermodulation. It is far more difficult to prevent spurious emissions from powerful transmitters in adjacent bands (e.g. TV or radar) spilling into the radio astronomy bands. Other problems include unwanted harmonics from transmitters at very different frequencies (e.g. police radio at 102 MHz with fourth harmonic at 408 MHz), frequency drift of transmitters (e.g. weather balloons in the band 403-406 MHz whose transmissions drift into the RA band due to temperature changes), spread spectrum transmissions, and finally spurious emission from industrial equipment which the owners do not realize are transmitting. In a crowded country it is impossible to track down all sources of interference.

The problems of sharing bands with active users are even more daunting. Separation distances required to meet the CCIR criteria are typically 100-10000 km. These are clearly unrealistic in small countries such as Britain and the Netherlands. There are peculiarly European problems too because of the different interpretations each country gives to the radio regulations and to the footnote status of radio astronomy in secondary bands (e.g. the 608-614 MHz band shared with TV broadcasting). The results of one country's actions are felt far beyond their own borders within Europe. Satellite transmissions pose a world-wide threat.

Given all these problems you might well ask, as our DTI has asked, how radio astronomy can survive at all in Britain. Why is there this apparent discrepancy with the CCIR recommended levels? The answer is that classical total power radio astronomy is unfortunately no longer viable in Britain at the lower frequencies. But the radio astronomy we do nowadays involves far more signal processing, and this provides some extra protection. When we carry out interferometry, pulsar or spectral line measurements, we are looking for signals with special characteristics. Broad-band noise which spoils a total power record may affect a narrow-band spectral line or pulsar measurement in only a minor way. Radio interferometers provide discrimination against interference on the timescale of the natural fringes. Thus our long-baseline interferometer MERLIN is able to integrate coherently on cosmic radio sources for many hours, whereas the interference affects the visibility function only on a timescale of a few milliseconds. This provides an extra 25 dB of protection, typically, over the CCIR recommended level. Levels of harmful interference calculated according to the treatment by Thompson (1982) are plotted in Fig. 2. This shows how the natural protection increases as the baselines increase. (The VLBI levels are derived from a separate requirement that the receiver noise should not vary by more than 1% during a measurement of fringe visibility). When our DTI first saw this diagram I had to explain why we could not do all our radio astronomy by VLBI!

One can turn the argument around. I have a simple-minded view of a radio astronomy quiet band protected from the great sea of man-made signals by the frail wall of radio regulations and good will. Despite all efforts, the sea makes inroads. In Britain, it has already swept over total power radio astronomy and is now lapping at single telescope spectral line and pulsar observations. The radio interferometers such as MERLIN and VLBI will be the last to go.

My own work is on cosmic masers. All the maser bands are shared active bands, and all have problems in Britain. Working up in frequency, the OH 1612

MHz band is shared with GLONASS and other satellite systems. You have heard plenty about GLONASS already. It is a problem for radio astronomers worldwide. In Britain the top end of the OH mainline band is shared with fixed services. Many spectra of the 1667 MHz line are corrupted as shown in Fig. 3, and must be reobserved. The OH 1720 MHz band is also shared with fixed services. The important new methanol maser line at 12.2 GHz has turned up in a satellite band (Batrla et al. 1987). There is no room for new discoveries. And finally we are trying to find a way of sharing the 22.2 GHz H_2O band with fixed services. This band has been used by UK radio astronomers since the early 1970s, but now it has become commercially attractive for short hop links ($\sim$10 km) onto telecommunication networks.

So much for the problems. What solutions are in sight? It is sometimes suggested that radio astronomers are not doing enough to protect themselves. However many of the technical tricks discussed by Rick Fisher have already been tried at various observatories, and they will need to be used more widely in the future. They are a remedy but not a cure. There is an ongoing task to raise awareness of our problem. I have found other users of the radio spectrum very understanding and sympathetic once the problem has been explained to them. We also need to coordinate our response and tackle the problem at the highest possible level through bodies such as IUCAF. It is a conservation issue, to preserve clear bands in the radio spectrum for future generations. The present radio regulations do not provide adequate protection for passive users of the spectrum. One can only hope that with advancing technology other wavelengths and other media such as optical fibres will offer the commercial users more bandwidth at a cheaper price, leaving the radio spectrum for those of us who can work at no other wavelength.

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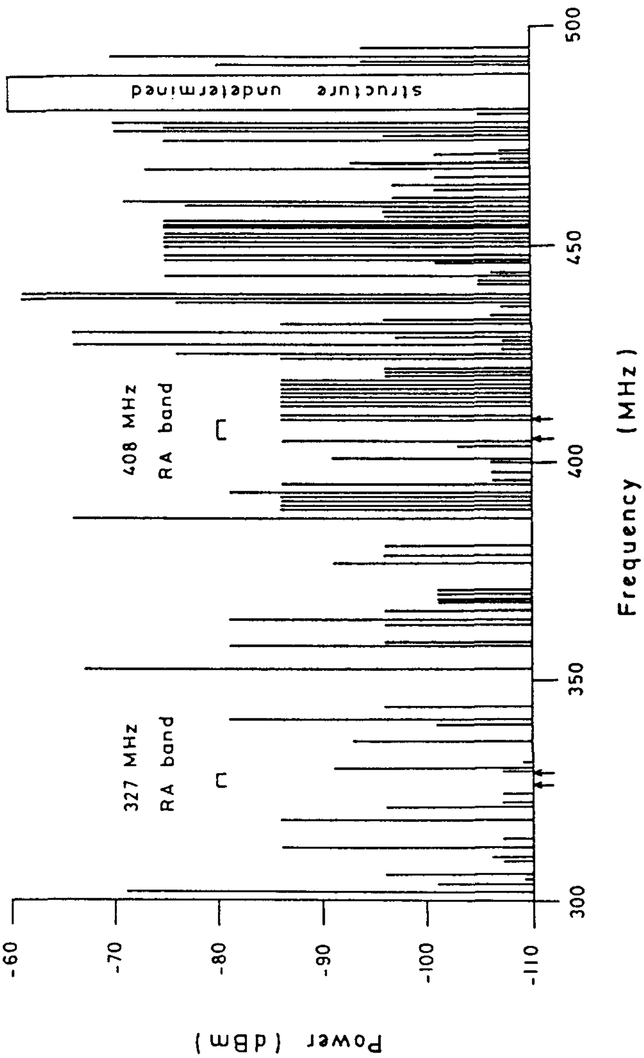

Fig.1 RF environment at Jodrell Bank, in the frequency range 300-500 MHz. Typical power levels are -85 dBm in a 20 kHz band. The radio astronomy bands are indicated.

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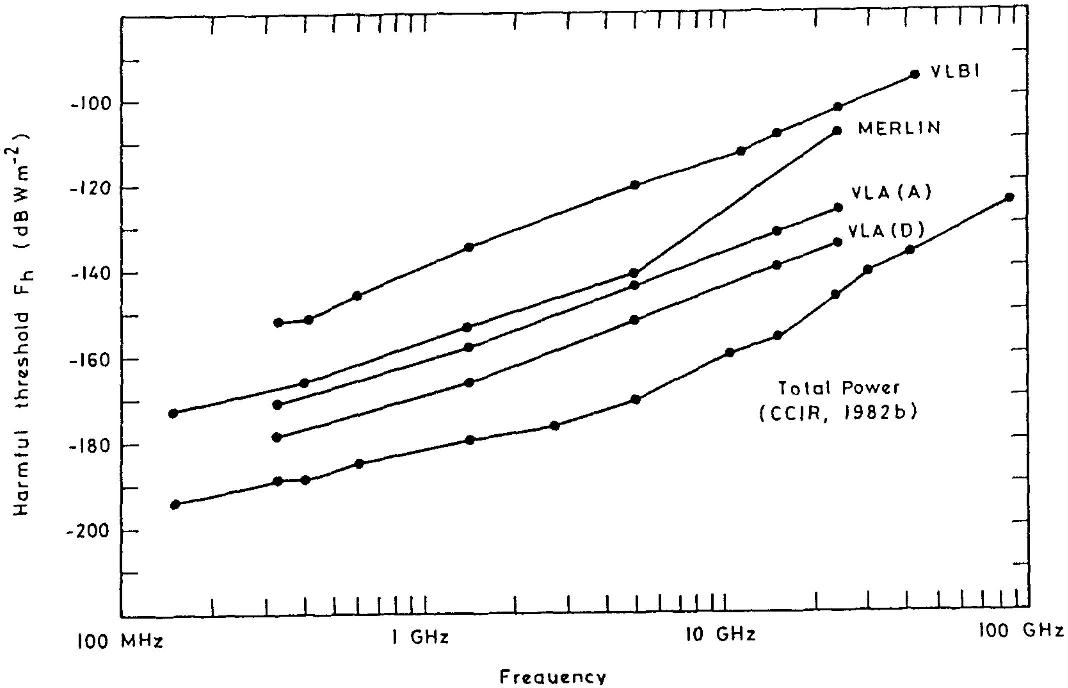

Fig. 2 Harmful thresholds of interference to radio astronomical measurements shown as a function of frequency. The lower curve applies to total power measurements using a single telescope, and is taken from CCIR Report 224. Connected element interferometers such as the VLA and MERLIN have a degree of extra immunity against interference which increases with the array size (expressed in wavelengths). The curve for VLBI assumes the interfering signal affects only one telescope, in which case the result is independent of the array configuration or size. Adapted from Thompson et al (1986).

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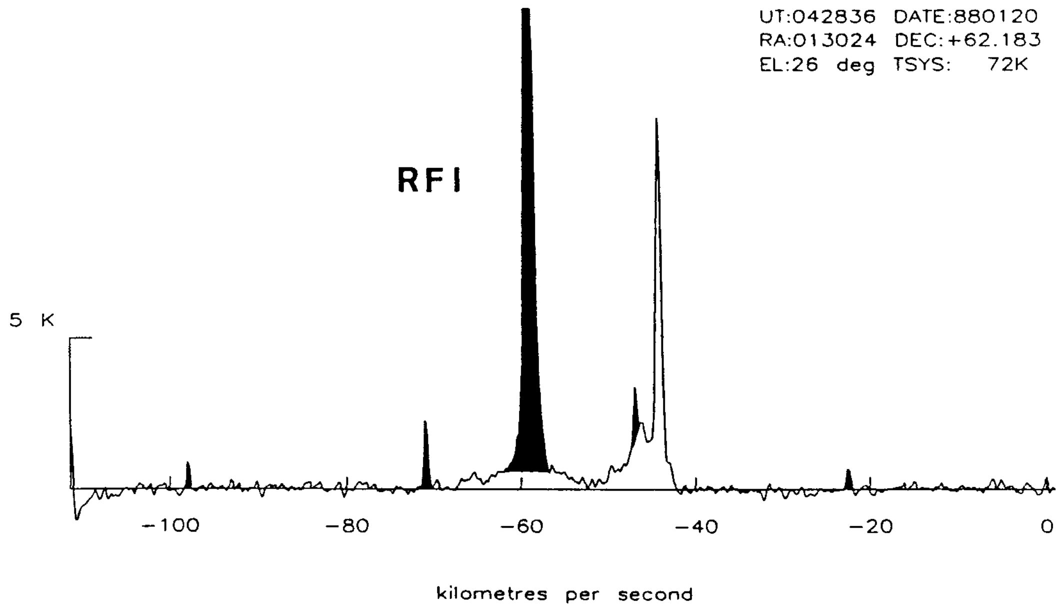

Fig.3 An example of interference to OH 1667 MHz spectral line measurements from fixed-link transmitters which share the frequency band in Britain. The RFI contribution is marked in black, and has been truncated for obvious reasons.

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