Instrumentation Beyond the Year 2000

Panel Discussion at the XII ERAM in Davos

On the occasion of the XIIth ERAM in Davos, a panel discussion organized on October 11, 1990, was devoted to "Instrumentation Beyond the Year 2000". Such a panel fitted well the general theme of the Davos meeting entitled "European astronomers look to the future", and was also a valuable follow-up to the panel of the previous day on "Cooperation in astronomy in the new Europe" (see a report by P. Léna in the *Messenger* No. **62,** p. 19–20, December 1990).

Four panel members presented their thoughts on "Radio astronomy in the year 2000, and beyond" (R. Booth), "Post VLT optics and telescopes" (R. Wilson), "The future of X- and γ-ray astronomy" (G. Bignami) and "Future far infrared and sub-mm astronomy" (R. Genzel).

Two other panelists had been invited but were not present: A. Finkelstein and A. Labeyrie, the letter having sent some transparencies for a short presentation of an optical very large array.

In the present issue of the *Messenger* we have the pleasure of presenting these contributions.

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Radio Astronomy – Towards the 21st Century

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1. Introduction

Advances in radio astronomy may be related to technical developments in several major areas. Among these I would list increased sensitivity of receivers and receiving systems, extended spectral range to cover the whole of the radio band of the electromagnetic spectrum, higher resolution – spectral, temporal and spatial (angular), together with improved data analysis facilities and techniques.

Radio systems have now reached a high degree of sophistication but improvements are certain in the 2000s especially in spectral range – the extension of the radio band to cover millimetre and submillimetre wavelengths and in angular resolution through VLBI.

2. Sensitivity of Receiving Systems

The performance of a radio telescope and associated receiver is characterized in terms of the figure of merit, G/T, where G is the system gain and T the equivalent noise temperature of the system. The gain of a telescope is given in terms of its area, A, wavelength, l by $4\varrho A/l^2$. This factor is further modified by an efficiency factor, h, related to the efficiency of illumination by the primary feed and the surface accuracy (an rms accuracy of l/20 reduces the gain by a factor of ~ 1.5).

2.1 Large telescopes for the 21st century

Large antennas are required to improve G and at centimetre wavelengths the ultimate size for a fully steerable telescope, in terms of cost, seemed to have been reached in the 100-m Effelsberg antenna. Its design is based on the homology principle where gravity deformations are constrained so that the primary reflector maintains a parabolic shape, albeit with varying focal length. The focal position changes with elevation angle and the primary feed or secondary mirror (when in Gegorian configuration) is moved to compensate. The success of the homology design is demonstrated by the fact that the 100-m telescope is still 30% efficient at a wavelength as small as 7 mm. The homology principle is adopted in most new radio telescopes.

The unexpected collapse of the 300-ft transit telescope at NRAO in W. Virginia has provided the incentive to build another large fully steerable antenna in the USA. This will be the new Green Bank Telescope which will have an unblocked aperture, 100 m in diameter. This will be achieved with an offset design involving a primary/Cassegrain secondary focus arrangement suspended on a large beam above the main reflector (see Fig. 1). I do not expect that there will be any further large telescope in the West, in the early 2000s at least, but we will see the completion of the Soviet 70-m telescope near Sammarkand. This antenna, and the Green Bank telescope will be operated at wavelengths down to 3 mm.

2.2 System temperature

Receiver noise temperatures, T_r have improved dramatically during the past 5 years through the use of high electron mobility transistors (HEMTs), cooled to physical temperatures of around 15 K, and at wavelengths down to about 1 cm, receiver noise temperatures are approaching the quantum limit, T_q. However, the total system temperature, T, has a number of other contributions.

$$T = T_q + T_{cb} + T_{at} + T_{sl} + T_r$$

where T_{cb} is the cosmic background temperature, T_{at} is the contribution from the atmosphere which is most severe at very long (m) and very short (mm) wavelengths due to the ionosphere and troposphere respectively, and T_{sl} represents the noise power picked up in the sidelobes. T_{sl} includes a contribution from man-made interference which has

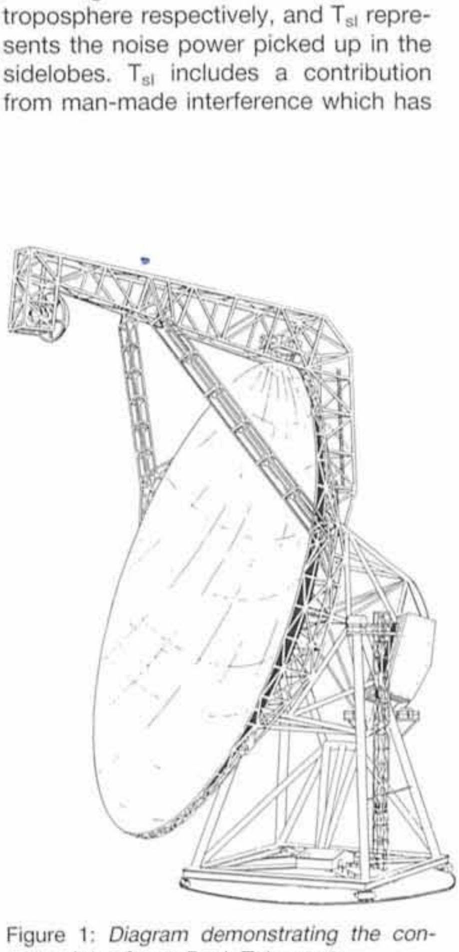

Figure 1: *Diagram demonstrating the concept of the Green Bank Telescope.*