PROPOSED VERY LONG BASELINE INTERFEROMETRY AT 103 MHz IN INDIA+

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Abstract: Three radio telescopes operating at 103 MHz are being installed at Ahmedabad, Rajkot and Surat separated by about 200 km from each other for observing interplanetary scintillations (IPS) of compact radio sources for study of solar wind plasma dynamics as well as radio source size measurements for cosmological studies. Of these, two radio telescopes at Ahmedabad and Rajkot have been commissioned and started synchronous daily observations of IPS of a few compact radio sources with relative time accuracy of about $\pm$ 1 millisec. The third telescope at Surat is expected to go in operation by the end of 1983. As soon as all the three telescopes go in for simultaneous operation, it is proposed to (1) augment the telescope sensitivity so as to detect sources with flux density $\sim$ 1 Jansky (2) incorporate better time and frequency standards at each station which can be synchronised to better than μs relative time accuracy (3) develop suitable receivers and data acquisition system for generating interference fringes using a general purpose computer and (4) take advantage of the availability of three telescopes to incorporate 'closure phase and amplitude' techniques which eliminate undesirable atmospheric and ionospheric phase distortions.

The paper describes (1) scientific objectives and motivation for carrying out VLBI measurements of compact radio sources at meter wavelengths and (2) conceptual system design.

1. INTRODUCTION

During the last couple of decades, high angular resolution observations of radio galaxies and quasars have been extensively carried out using Very Long Baseline Interferometry technique (Miley 1980 and references therein). At centimetric wavelengths the angular resolutions achieved so far have been of the order of 10^{-4} arcsec. In recent years two-dimensional mapping of some radio sources has also been successfully carried out and their structural changes that occur from year to year have also been detected. Study of angular structure of radio sources gives information about the mechanism of production of these radio sources, their

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their physical environment and cosmology. Among the problems which have been studied so far include diffuse emission, "hot spots", cores and jets that constitute these radio sources. However, most of these angular structure studies have been carried out with a network of radio telescopes operating at decimetre and centimetre wavelengths using VLBI technique. Similar studies at meter wavelengths need to be carried out for the understanding of the outer envelopes of compact radio sources wherein initially accelerated electrons loose their energy by radiation and begin to radiate predominantly at longer wavelengths. Hence there is a strong case for making systematic observations at metre wavelengths using VLBI. Unfortunately, longer wavelength radiations (metre and decametre -λ) are adversely affected in intensity and direction of arrival due to scattering and refraction during their propagation through earth's ionisphere, interplanetary and interstellar medium, which limits the angular resolution of a terrestrial radio telescope and introduces positional errors. It has recently been demonstrated that if one has 3 or more radio telescopes available for observations, then one can exploit 'closure Phase' technique (Wilkinson et al. 1977) which eliminates the effect of turbulence in the propagation medium, thereby allowing determination of direction of arrival of radiation unambiguously.

This paper describes an outline of the proposed plan to initiate VLBI technique at a frequency of 103 MHz in India using radio telescopes being set up for interplanetary scintillation studies.

2. DESCRIPTION OF AN IPS RADIO TELESCOPE AT 103 MHz

The Physical Research Laboratory, Ahmedabad (India) has been engaged in setting-up an observatory consisting of three radio telescopes operating at 103 MHz, for studies in solar wind plasma and radio source structures using IPS technique. Under this project, the three telescopes which are separated from each other by about 200 km would be set-up in Western India, in the State of Gujarat as shown in Figure 1. Of these, two radio telescopes at Ahmedabad and Rajkot have been commissioned and started daily simultaneous observations of IPS of a few compact radio sources with a relative accuracy of $\pm$ 1 ms. The third telescope is expected to go in operation at Surat by the end of 1983. The description of one of the IPS telescopes has been published (Alurkar et al. 1982).

Figure 2 shows the block diagram of the IPS radio telescope. Briefly, the telescope consists of a full-wave dipole array of 64 rows, each one consisting of 16 dipoles. The antenna array has a rectangular aperture of 5000 square metres; 200 metres in the North-South and 25 metres in the East-West direction. The aperture is divided into two halves and the telescope is operated as a correlation interferometer thereby enabling recording of sine and cosine fringes. The sensitivity of the telescope is such as to detect sources with 5 Janskys at signal to noise ratio of 5. The telescope has a beam width of 2° in declination at the zenith and 7.5° in right ascension. The telescopes will be operated as a transit instruments each day for recording interplanetary scintillat-

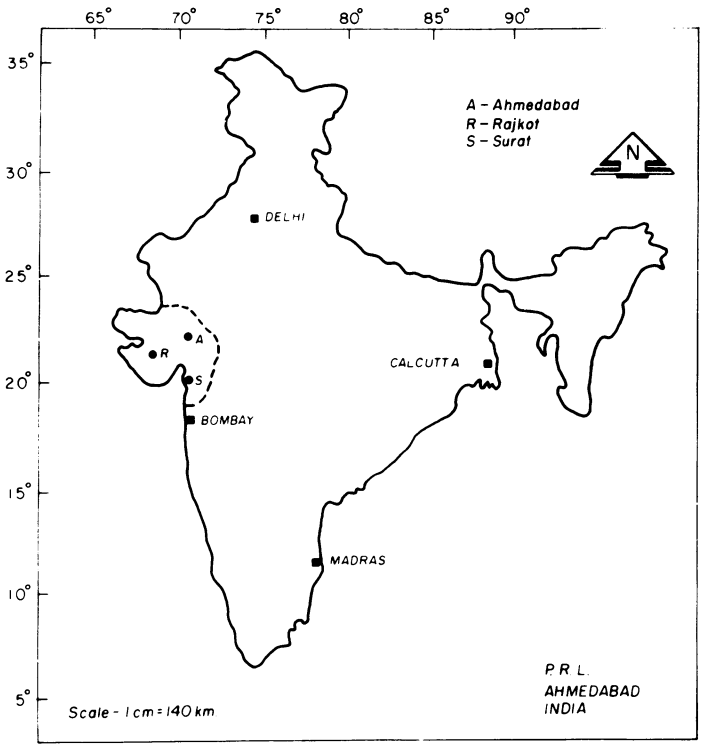

Figure 1. Location of three radio telescopes for IPS experiment in India.

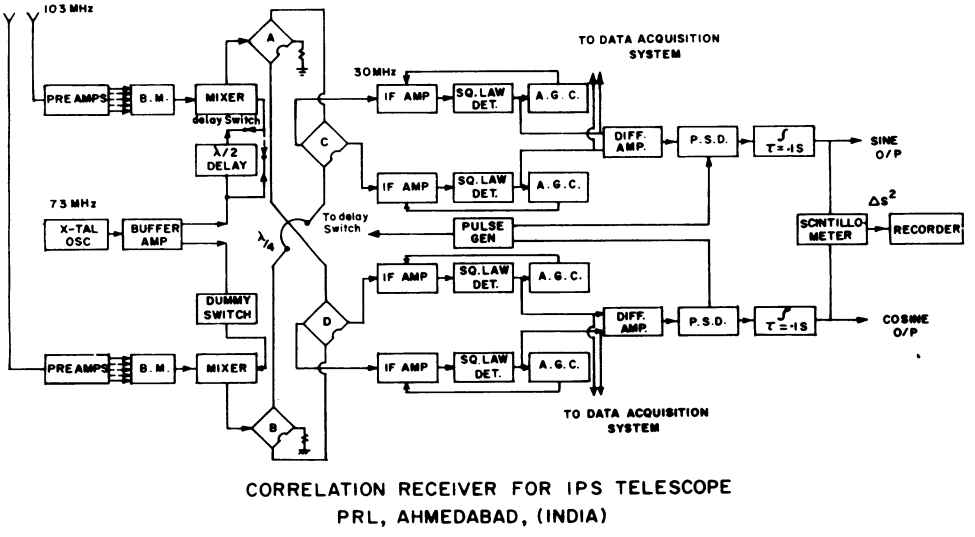

Figure 2. Block diagram of an IPS radio telescope at 103 MHz.

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ions of selected radio sources simultaneously from 3 stations. Presently, the relative time accuracy is maintained within few milliseconds. The correlation interferometer data (sine and cosine outputs) are recorded on charts for monitoring purposes and digitized and recorded on magnetic tapes, compatible with a general purpose computer. The data from three stations will be auto- and cross-correlated for computation of the solar wind velocity. Using single station IPS data, radio source structure studies have also been initiated.

3. PROPOSED MODIFICATION OF IPS RADIO TELESCOPE FOR VLBI

Since three identical radio telescopes will be available by the end of 1983, we propose to modify this system to operate in the VLBI mode to yield an angular resolution of 3 arcsec at 103 MHz as follows:

1. Since the presently available time accuracy of the order of few milliseconds will be insufficient, it will be necessary to incorporate Rubidium Vapour time and frequency standard, which will yield relative time accuracy between two telescopes of about a microsecond.

2. The local oscillator voltages will be derived from these Rubidium frequency standards.

3. The IF output will be digitized using 1-bit digitization scheme. These data will be recorded on video tape recorders with frequency response up to 2 MHz. These data will be cross-correlated to produce interferometer fringes using a general purpose computer and will be used to attempt closure phase and amplitude techniques.

The block diagram of the proposed VLBI terminal is shown in Figure 3. Most of the specifications of this terminal are similar to the NRAO mark II Tape Recorder system (Clark 1973, Cohen 1973). The antenna is connected to a low noise preamplifier (LNA) in order to overcome the losses due to long cable lengths from antenna to the receiver. The local oscillator voltage is derived from the highly stable Rubidium Vapour frequency standard. The amplified signal from antenna is then mixed with LO to get an IF output which is in turn further amplified. The IF output is then amplified and clipped, by fast saturating amplifiers, sampled and recorded on a video tape transport along with timing information. The time at VLBI station will be synchronised using a potable atomic clock to an accuracy of about 1 μsec. The data so recorded will be brought back to a central computer for processing to search for interference fringes.

After demonstrating the feasibility of 'closure phase and amplitude' techniques with the modified set up, additional radio telescopes with tracking capability will be installed to obtain various baselines to give adequate uv coverage for mapping of radio sources at metre wavelengths.

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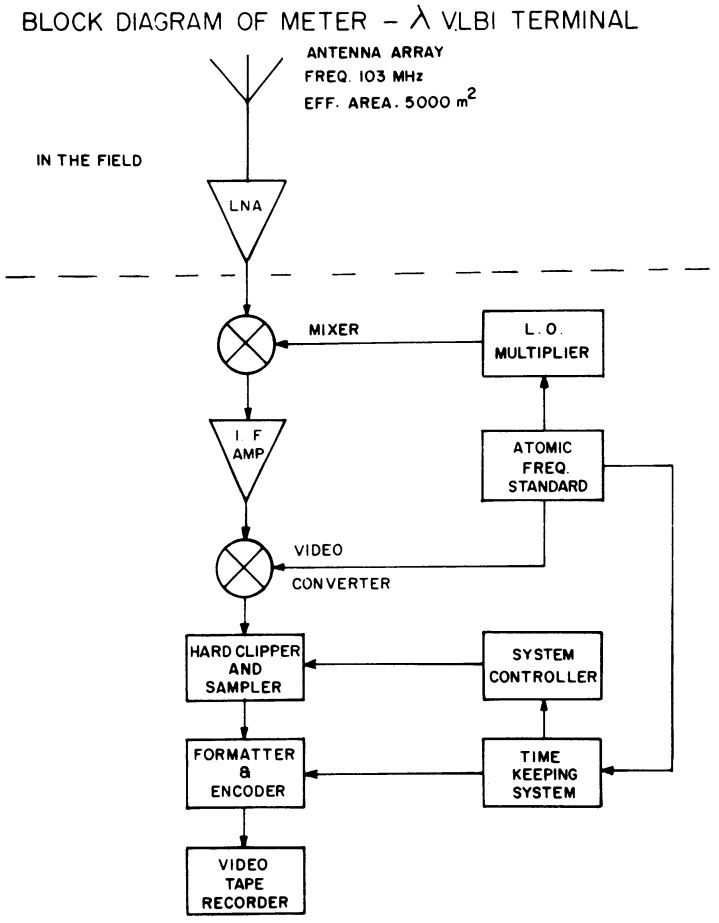

Figure 3. Proposed VLBI terminal at 103 MHz

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