

VII. MICROWAVE AND MILLIMETER WAVE TECHNIQUES

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

1. Low-Temperature Millimeter Wave Receivers

Joint Services Electronics Program (Contract DAAB07-71-C-0300)

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This program is directed toward the development of extremely sensitive coherent receivers at millimeter wavelengths. Initial work involves development of cryogenic mixers and IF amplifiers, with emphasis placed on accurate modeling of the device properties so that optimization can be performed and performance limits established.

The initial experimental mixer program involved fabrication of a 118-GHz mixer, which is nearly complete. The mechanical, dc, and IF properties of the mixer will be tested during the next few months, and the 118-GHz properties will be determined when appropriate test equipment is obtained. The very careful mechanical design should permit operation at 77°K and perhaps at 4°K. The diodes are Schottky-barrier GaAs devices obtained from the M. I. T. Lincoln Laboratory and from Hughes Aircraft Company. Diode diameters are in the 1-12 μm range. The diodes have gold terminals contacted by a whisker.

Initial dc measurements of diode properties reveal that cooling to 77°K improves performance, but the degradation factor η increases from ~ 1 to ~ 2.4 . We are beginning experimental determination of the mixing properties of such cooled diodes near 23 GHz, and comparison with theoretical models should soon be possible.

The initial theoretical analysis of single-diode mixers involves a resistance and inductance in series with a nonlinear resistor in parallel with a nonlinear capacitor. The effects of the waveguide structure are included. Transit-time effects, various noise mechanisms, and multiple-diode configurations will be included later.

Initial device goals for this program involve developing a single-sideband mixer with noise temperatures near 100-300°K at 3-mm wavelength.

An effort to develop cooled GaAs FET IF amplifiers is also under way. These broadband amplifiers will operate at frequencies as high as several gigahertz.

2. Microwave Measurements and Instrumentation

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A phase-stable microwave aperture synthetic interferometer has been constructed at the Haystack Observatory, Tyngsboro, Massachusetts. Instrumentation is proceeding

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and it will be used initially to measure refraction and absorption effects in the atmosphere at centimeter and millimeter wavelengths. Initially, the cosmic H₂O maser sources will be used as the test transmitter, and we expect to be able to measure refraction effects with an accuracy of a few hundredths of a second of arc. A phase reference system is being developed that makes use of a modulated laser beam, and the phase-locked local oscillator system will utilize a Gunn diode oscillator that we have developed. A cooled mixer with very low noise temperature will be developed for use with this system.

3. Very Long Baseline Interferometry

Joint Services Electronics Program (Contract DAAB07-71-C-0300)

B. F. Burke

Accurate positions of cosmic radio sources will be determined, and we shall make geodetic and time-comparison measurements of very high precision on Earth.

The method involves using two or more radio telescopes simultaneously as interferometers, with atomic frequency standards and precision video data recording employed. The data are processed by computer, and the results permit baseline measurements of better than 1-m accuracy, relative time comparisons to 10^{-15} s, and cosmic source position determination with an accuracy of 0.1 sec of arc.

A series of observations of strong H₂O maser sources has been completed jointly with the Naval Research Laboratory, to determine the position and stability of positions of the sources. New techniques of data processing have made it possible to produce maps of relative source positions with greater accuracy than could be done previously.