

XI. RADIO ASTRONOMY*

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RESEARCH OBJECTIVES

This recently formed group is interested in geophysical and astronomical experiments in which the techniques of radio astronomy, primarily at microwave wavelengths shorter than 3 cm, are used. The experiments that we have planned can be divided into two groups: 1) those directed toward studying the terrestrial atmosphere, and 2) those directed toward studying the microwave emission from extraterrestrial radio sources. Each of these groups can be subdivided into ground-based experiments and experiments to be conducted from balloon-borne platforms or space craft. In the millimeter range of wavelengths, many molecular resonances occur among molecules that are abundant in the earth's atmosphere and that may be expected to be present, to a greater or lesser degree, in planetary atmospheres. Obvious examples are O_2 , H_2O , O_3 , and the oxides of nitrogen. Many of these molecules play major roles in geophysical and meteorological phenomena of the terrestrial environment and their study by microwave techniques will give valuable information concerning their abundance, spatial and altitude distributions, temporal variations, and so forth. Also, the resonance lines afford a means of probing the atmosphere from which temperature and pressure distributions may be obtained. For the atmospheres of other planets, the simple detection of any molecular resonance, either from ground-based observations or from observations from a planetary space probe will be extremely valuable, from both the scientific and technological viewpoints. The problem of communication with an instrument package parachuted to a planetary surface will depend to a large extent on the radiofrequency properties of the planetary environment.

At wavelengths of 4 mm, 8 mm, and longer than approximately 1.5 cm the terrestrial atmosphere is sufficiently transparent to allow observations of celestial radio sources from the earth's surface. At millimeter wavelengths, observations with high angular resolution will permit mapping of the radio brightness distribution of the lunar surface and solar atmosphere. The measurement of planetary radiation will extend the radiofrequency spectrum and shed light on the physical processes responsible for the emission. As antennas and radiometers become available, the observations can be extended to the stronger radio sources beyond the solar system. The ground-based observations will be performed with an antenna suitable for millimeter use, which is now being constructed for the Research Laboratory of Electronics, and also with the larger antennas available at Lincoln Laboratory. With the latter antennas the experiments can be conducted profitably over a wide range of wavelengths extending to approximately 1.5 cm, and can include many sources external to the solar system.

The instrumentation to carry out these experiments, especially the radiometers in the millimeter range, require considerable development. Since systems packaged for space flight must meet rigid requirements with regard to weight and power, emphasis will be placed on solid-state components, particularly to meet the local-oscillator requirements. Since the molecular resonances are pressure-broadened to several thousand megacycles, effort will be concentrated on developing systems to detect these wide spectral lines.

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This research is being supplemented by an investigation of the theoretical aspects of the general problem of microwave propagation in a planetary atmosphere. This research includes the computation of resonant line shapes under conditions of varying pressure and temperature, the effect of foreign gas pressure broadening, and the effects of possible planetary clouds and/or ionosphere. These computations will aid in the interpretation of the observations and the planning of future experiments, particularly those from space craft.

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