resolved satellite lines, Doppler-shifted away from the much stronger terrestrial water vapor lines. Their preliminary results both confirmed the correctness of the results from Stratoscope II and also demonstrated that perhaps all possible avenues open for the study of this problem had not been fully exhausted.

Co-hosts of this 113th meeting of the American Astronomical Society were the University of Arizona and the Kitt Peak National Observatory. The next meeting will be held at the University of Alaska, College, 22–24 July, immediately following the total solar eclipse which will be visible there on 20 July.

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Plasmas: Wave Interaction and Dynamic Nonlinear Phenomena

The study of wave interaction and nonlinear phenomena in plasmas and ionized media has become in recent years a subject of great importance not only to physicists and engineers, but also to wave propagation theoreticians. Pennsylvania State University, whose Ionosphere Research Laboratory has a traditional interest in ionospheric wave interaction phenomena, arranged a conference on wave interaction and dynamic nonlinear phenomena in plasmas. Outstanding investigators from universities and industrial laboratories attended the meeting (4–6 February). In order to make the sessions more effective a limited number of speakers (about 15) were invited, and no attempt was made to arrange or group papers into areas; instead, papers were randomly arranged since mixing of the workers in vastly differing areas of specialities was one of the objectives of the meeting.

Basic wave interaction and dynamic nonlinear phenomena have much in common and scientists and engineers working in these diverse fields, which range from the high-power klystron studies to the plasma physics of the sun, greatly benefited from being brought together to exchange views and theoretical ideas. The high-power tube engineer, who deals with the "cleanest" of all plasmas, has advanced the analysis of nonlinear phenomena and had valuable information for those scientists who have to work with less

clean plasmas. A comparison with the developments in solid state physics is not out of place in this connection. Without the availability of the basic clean and well understood solid into which impurities gradually were introduced, the entire field of transistor and maser physics and engineering would not have developed to its current state.

Interest in plasma is exhibited in many different areas of research. In astronomy, plasma physics is of importance since stars exist in a highly ionized state. Much work of theoretical importance has evolved from the study of the astrophysicist, and a great deal of this work is of importance in understanding thermonuclear fusion and the high-temperature plasma which results. Aerodynamicists are concerned with high-temperature plasma produced when high velocity vehicles re-enter the earth's atmosphere. In addition, wave propagation theoreticians have been concerned with the plasma sheath which surrounds the vehicle; this sheath can drastically affect radio communications with ground-based stations.

Other research has covered nonlinear phenomena in plasma of two distinct kinds. The first, known as the Luxembourg effect, was discovered about 1939 and consisted of the transferring of the modulation of one high-power radio signal onto the carrier of another radio signal; both were of different radio frequencies but passed through a common region of the ionosphere. This effect, caused by the local heating of the plasma (the ionosphere) by the one signal, perturbs the propagation parameters of the medium at the modulation frequency and transfers this modulation to the second radio signal. This effect has been a very useful tool for studying the ionosphere and for making sensitive measurements of the characteristics of laboratory plasmas.

The second nonlinear process is the modulation of the electron density of a plasma by, for example, a high-power radio signal. It is this spatial perturbation of the density occurring whenever a powerful signal creates significantly large electron excursions that accounts for the nonlinear phenomena. This latter type of nonlinearity, rather than that due to "heating," was the main theme of the conference.

Nonlinear phenomena exhibit certain inhibitory effects; they limit the output of present-day high-power klystrons. High-power plasma amplifiers, which may be serious competitors to high-power klystron devices in the future, will also have their ultimate power output limited by nonlinear effects. The plasma amplifier in its present form makes use of the interactions between electron streams, plasma oscillations, and slow wave plasma modes (so-called "whistler" modes). In principle this device is extremely simple; the plasma replaces the slow wave structure of more "conventional" amplifiers, for example, the traveling wave tube or the klystron with floating cavities. Such plasma amplifiers have already been designed to operate in the millimeter wave range.

As far as wave interaction effects are concerned, they are very similar to those in the plasma amplifier and are likely to take place in the exosphere when streams of charged particles impinge upon the same. This may cause the audio frequency whistler hiss which is recorded during periods of strong geomagnetic activity.

Nonlinear phenomena occurring in the ionosphere include ultrahigh-frequency radiation effects and resonance and parametric amplification effects. Ultrahigh-frequency phenomena take place in the solar corona (the solar ionosphere) during intervals of enhanced solar activity; "second harmonics" of solar radio noise outbursts have been

recorded on several occasions. Since a third harmonic has never been reliably recorded, it is believed that the "fundamental" radiation frequency actually is a subharmonic and that parametric amplification or generation of radio waves takes place in the coronal plasma when the primary radiation is very intense. The exciting agent may be, for example, an ionized stream as in the plasma amplifier, an electromagnetic wave, or a mixture of both.

Nonlinear resonance and parametric amplification occurs for the most part in the top-side region of the ionosphere. "Top-side" ionospheric soundings by the Canadian Alouette Satellite have shown, for example, that it is possible to excite the fundamental electronic cyclotron resonance of the medium by harmonic pumping; actually harmonic (or parametric) pumping has been possible with frequency ratios as high as ten or more. If future "top-side" sounders are equipped also with harmonic receivers, it is most likely that other interesting non-linear phenomena will be observed.

Nonlinear wave and interaction phenomena are very important also in the fields of high-power sound, underwater sound, and in high-power laser physics and engineering, including future laser communication systems. The arranging committee for the conference believes that representatives from these fields of scientific and engineering endeavor should continue the practice of holding symposia similar to this type.

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Transplutonium

In order to mark the near completion of the new hot laboratory of the chemistry division at Argonne National Laboratory about 250 scientists from 12 countries attended a symposium on the transplutonium elements at Argonne, Illinois (15–17 May). Discussions reflected four characteristics of research with the very heavy elements: (i) the