MIDWEST SOLID-STATE PHYSICS CONFERENCE

A report by ***Robert J. Friauf***

MASERS, rasers, growth of whiskers—these were among the things discussed at the 1958 meeting of the Midwest Solid-State Physics Conference, which was held on November 1 at the University of Kansas in Lawrence. Some seventy persons were in attendance, representing institutions in six midwestern states.

This was the sixth meeting of the conference, which has met annually, with one exception, since its inception at Purdue University in the fall of 1952. Other host institutions have been Iowa State College, the University of Minnesota, the University of Missouri, and The University of Chicago. Aside from the brief, intense labors of the host, the conference is remarkable in having no organization, no bureaucracy, no red tape. This feature, coupled with the lack of a need for multiple sessions or written abstracts, has lent an informal charm that is too often missing in larger meetings.

Those who support the conference feel that it serves a number of purposes. Paramount among these is the need for persons in this area, many of them in physics departments which do not have an extensive program in solid-state physics, to communicate with other members of the same species. Thus old and new friends can be met, and acquaintance with current research in the area can be maintained. For graduate students the chance to hear about other kinds of research is especially important, and there is also the opportunity to gain experience in presenting papers at a meeting where the hand on the timer may be just as firm as at more formal meetings but where the mien of the moderator is likely to be less awesome.

The program provided for a busy Saturday, beginning with tours of the laboratories in the early morning. Then in addition to morning and afternoon sessions of contributed papers, fifteen in all, there was an invited address following the noon luncheon, which must serve as a banquet for this meeting. The speaker for this occasion was Professor N. Bloembergen of Harvard University, who talked about solid-state masers.

After pointing out that Webster identifies a "mazer" as an old Scotch drinking cup, usually associated with trickery, Professor Bloembergen proceeded, by means of an admirable survey lecture, to convince everyone present that masers are really very easy to understand. He discussed the principle of operation of two- and three-level masers, the very desirable low noise characteristics of masers, and the application of masers to radio astronomy. (A photograph showed a maser, complete with a liquid helium dewar sitting all by its lonesome self at the focus of the Naval Research Lab radio telescope!) Mention was made of possible contemplated devices including a multiple-level maser to amplify at frequencies *higher* than the pumping frequencies and a microwave quantum counter, and in response to a question, the principle of maser action was contrasted to that of the ferromagnetic amplifier of Suhl.

The contributed papers represent some of the current or recently completed research at the various universities of the area and cover a wide range of interests as shown in the following survey. Newton Bernardes (Washington University, St. Louis) described a theory of solid Ne, A, Kr, and Xe. Starting with an empirical interatomic potential deduced from the gas phase, he has computed, by a variational procedure, the energy, volume, and compressibility in fairly good agreement with observations. The quantum effects are scarcely

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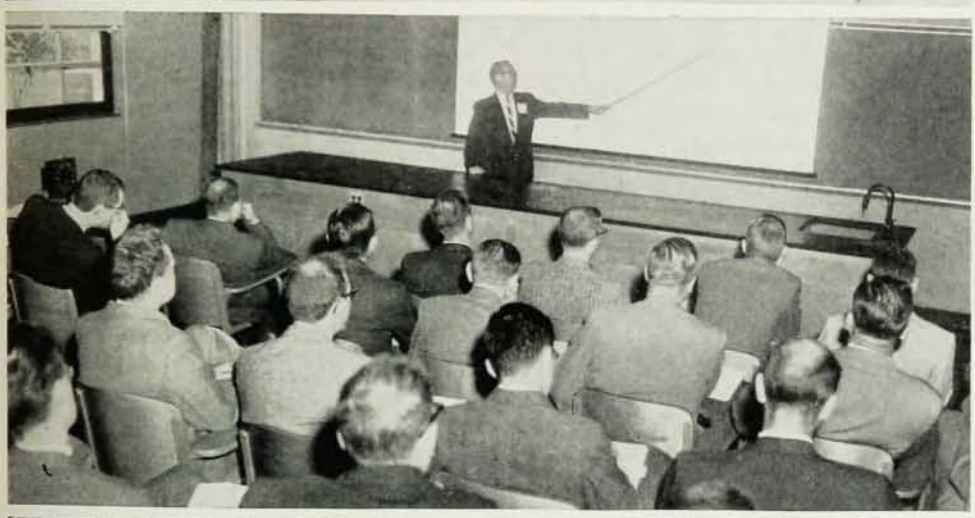
N. Bloembergen of Harvard University addresses the luncheon session on solid-state masers.



The morning session opened in a classroom in Malott Hall with a paper by G. Fox of Iowa State College.

Graduate students from Iowa State College listen as R. C. Sapp (at left) of the University of Kansas discusses the 25-kilogauss magnet installation for adiabatic demagnetization.

apparent for Xe, but amount to 15 percent for Ne; these effects would be much more noticeable at pressures of 20 000 atmospheres. Conrad Trulson (Iowa State College) reported measurements of the vapor pressure of a number of rare earth elements. By using a Knudsen effusion technique with a mass spectrometer, it is possible to cover five cycles of vapor pressure in thirty minutes; from the measurements the heat of sublimation is calculated with the Clausius-Clapeyron equation. Since these elements have three incomplete electronic shells, it is difficult to compute the cohesive energies from theory; it appears, however, that samarium, europium, thulium, and ytterbium, which display divalent tendencies, also have lower cohesive energies. G. Fox (Iowa State College) described experiments on the ionization of rare earth atoms at metallic surfaces such as tungsten and iridium. The value of the work function of the metal, which can be calculated from the measurements by the Saha-Langmuir equation, appears to be about one electron volt higher than the

value obtained from thermionic emission, which is in a way the inverse process. It was brought out in the discussion that thermionic emission would be favored at regions of the surface of low work function, whereas ionization of an atom would be favored at regions of high work function; the observed variation of work function with orientation of the surface is of this order of magnitude for tungsten and would appear to account for the seeming discrepancy.

On magnetic matters, a phenomenological theory of the magnetic properties of dysprosium was given by S. H. Liu (Iowa State College). A two sublattice model was proposed, with strong magnetic coupling within each sublattice of the hexagonal close packed structure but weak coupling between the sublattices. The theory can account for a discontinuous jump in the magnetization as the magnetic field is increased, for the change from antiferromagnetism to ferromagnetism as the temperature is lowered, and for the anisotropy in the antiferromagnetic region on the basis of Zener's theory, which proposes that the anisotropy coefficient should vary as the *twenty-first* power of the magnetization! Richard Sapp (University of Kansas) described a preliminary experiment to determine whether any force is exerted by a magnetic field on a current in a superconductor. The force when the metal, tin, is in the superconducting state, appears to be much less than the Lorentz force; the results may be qualitatively in accord with the London theory. William A. Barker (St. Louis University) could not resist the temptation to mention that his *raser* had nothing to do with the *growth of whiskers* reported below. His proposal is to obtain an inverted population in the nuclear spin system of Ag^{109}, which has a negative magnetic moment, by saturating the electron spin resonance in silver with microwave power and making use of an inverted Overhauser effect. If this can be accomplished, amplification at radio frequencies (1.98 mc/sec for 10 kilogauss) can be carried out in a manner similar to that at higher frequencies in the *maser*. Experiments are proposed but may prove difficult because the electron spin resonance in silver has not yet been detected, presumably because of spin-orbit broadening.

On the subject of defects in solids, the growth of whiskers—crystal whiskers, that is—was discussed by Dean Dragsdorf (Kansas State College). According to the usual picture of a single screw dislocation along the center of the whisker, Eshelby has predicted a twist of the lattice during growth of the whisker. This twist shows up in a tilt of some of the x-ray diffraction lines, and from this tilt it is possible to calculate the length of the Burgers vector of the dislocation. A striking demonstration of the atomic nature of dislocations is that in whiskers of corundum (Al_2O_3) this length is sometimes twice, sometimes nine times—but always a small integer times—the length of the *c*-axis. The diffusion of donors in oxide coated cathodes such as BaO has been studied by Koji Okumura (University of Missouri) by observing the electron emission from various regions of a sample activated by a localized nickel-aluminum alloy. The observed activation energy of 0.43 ev appears to support previous ideas that the diffusing donors are interstitial barium ions rather than oxygen ion vacancies. Robert J. Friauf (University of Kansas) presented preliminary measurements of the diffusion of radioactive thallium in thallium chloride; the observed diffusion coefficient is much smaller than the value predicted from the ionic conductivity by the normal Einstein relationship. The question remains open whether this effect is due to the presence of Schottky defects, with chlorine ion vacancies much more mobile than thallium ion vacancies, or to the presence of Frenkel defects, with the low diffusion coefficient caused by large correlation effects in the thallium interstitialcy motion.

Concerning electronic processes in solids, Bernard Goodman (University of Missouri) discussed the application of second quantization to nonorthogonal states; the advantage of this method is that it makes possible the calculation of matrix elements in the many electron problems without becoming involved in determinantal wave functions as in the work of Löwdin. A suggested application is the treatment of excitons in ionic crystals, with regard, for instance, to the reason for the appearance of an extra line in the fundamental optical absorption of CsI. N. Pearlman (Purdue University) presented a study of thermal conductivity and thermoelectric power at low temperatures in a series of *p*-type semiconducting samples with varying acceptor concentrations, one sample being nearly completely compensated. Noticeable differences appear in both properties for the various samples, and it is hoped that a better understanding of phonon-electron interactions can be obtained from the results.

A technique for cleaving diamonds in vacuum in order to study possible surface conduction on clean surfaces was shown in a film by D. A. McWilliams (Iowa State College). The design and construction of a paramagnetic resonance spectrometer for the study of color centers in alkali halides was discussed by Glenn Conklin (University of Kansas). A thermodynamically consistent phase diagram of teflon showing high pressure phase changes was reported by Robert I. Beecroft (Iowa State College).

In addition to the people on the program, other persons who were active in supporting the conference are Don Hudson and R. H. Good, Jr. (Iowa State College), Eugene Hensley (University of Missouri), Gordon Gross and Sheldon Levy (Midwest Research Institute, Kansas City), Edgar Pearlstein (University of Nebraska), and J. D. Stranathan and Gordon Wiseman (University of Kansas). In contemplating the location of future meetings, the problem inevitably arises that the diffusion length for one day's drive is of the order of 300 miles, whereas the linear dimensions of the Midwest, from Indiana to Kansas or from Minnesota to Missouri, exceed 500 miles. Partly for this reason, tentative plans for next year are to meet at Iowa State College, which is located approximately at the center of gravity of the area.