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MEETINGS AND CONFERENCES

ALL-UNION SEMINAR ON EXCITONS IN CRYSTALS

E. F. SHEKA

Kiev Institute of Physics, Academy of Sciences, Ukrainian S.S.R.

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THE first All-Union Seminar on Excitons in Crystals, meeting at the Institute of Physics of the Academy of Sciences of the Ukrainian S.S.R. in Kiev on December 8 and 9, 1965, was presided over by Academician I. V. Obreimov. The Institute had arranged the seminar to bring together specialists in solid state physics who are investigating exciton states in nonmetallic crystals. The 75 participants came from several of the leading scientific institutions of the U.S.S.R. Academy of Sciences, the Academies of Sciences of the Ukrainian S.S.R., Estonian S.S.R., and Moldavian S.S.R., the S. I. Vavilov State Optical Institute, the V. I. Lenin Moscow State Pedagogical Institute, and the Kiev and Chelyabinsk State Universities.

At this first seminar singlet exciton states in crystals were discussed. Excitons in molecular crystals were discussed principally; these have been observed experimentally by Academician A. F. Prikhot'ko at the Institute of Physics of the Ukrainian Academy of Sciences, where they were also interpreted theoretically by Academician A. S. Davydov. Beginning in 1946 extensive experimental and theoretical investigations have been conducted at Kiev to determine the role of excitons in several important processes within nonmetallic crystals—absorption and luminescence spectra, photoconductivity and photochemical transformations, and mechanical and other external influences affecting the crystal lattice. Two reports were presented as a basis for discussions. Academician **A. S. Davydov** of the Ukrainian S.S.R. (Kiev Institute of Physics) reported on the latest theoretical investigations of exciton energy bands in crystals. He was greatly concerned with a comparison of Frenkel and Wannier-Mott excitons from a single theoretical point of view. Davydov defined an exciton as an excited crystalline state having energy that is a function of a wave vector **k**. This quantum number of excitons can have continuous values (in infinite crystals) or discrete values (in finite crystals). He reviewed the present situation with regard to exciton band calculations in both the Soviet and foreign literatures. Commenting on the faults of previous calculational methods, he reported the first theoretical calculations of the structure of singlet exciton bands in complex anisotropic molecular crystals for the entire range of quasimomentum values; numerical calculations for an anthracene crystal served as an illustration. Davydov discussed the assumptions on which the calculations were based. In conclusion he indicated the problems that he would consider in the very near future. These include investigations of 1) exciton-photon interaction and 2) interaction between a photon, exciton, and phonon. The solution of the problems is required before a closed theory can be constructed for light absorption in crystals making transitions to exciton states.

V. L. Broude (Kiev Institute of Physics) spoke about experimental methods for studying the structure of exciton bands in molecular crystals. He discussed several methods developed by himself and his collaborators at the Institute of Physics of the Ukrainian Academy of Sciences. The theoretical justification of these methods has been given by É. I. Rashba (Kiev Semiconductor Institute). The successful treatment of the experimental results on the basis of the theory has led to several results of fundamental importance. The isotope effect provides the principal method for investigating the structure of exciton bands. By analyzing the low-temperature absorption and luminescence spectra of an isotopic impurity having an energy level close to the exciton band of the solvent crystal it became possible to determine the width of the exciton band, and the signs of effective masses in the region of small **k**, and also to calculate for the first time the effective exciton mass for the lowest state of a naphthalene crystal. These studies were made on crystals of naphthalene and benzene mixed with their deutero isotopes.

Another method of studying the structure of exciton bands consists in an investigation of the temperature dependence of the widths of electron-vibrational bands in the exciton luminescence spectrum. Since an electron-vibrational transition involves three particles—a photon, exciton, and phonon (intramolecular vibration)—the selection rule $k_{el} + k_{phon} = \mathbf{q}$ (where **q** is the photon momentum) allows transitions from all points of the exciton band. Thus, in the case of a weak exciton-phonon interaction at a sufficiently high temperature to fill all sublevels in the exciton band, the band width of the electron-vibrational transition reflects the exciton band width; the phonon band width is usually small. This method was applied to the exciton luminescence spectra of naphthalene and benzene crystals.

New possibilities for the study of exciton band structure are found in the investigation of effects associated with the decay processes of electron-vibrational molecular excitation through resonance interactions in crystals. Under certain conditions these processes permit crystal excitations resulting from the absorption of single photon, exciton, and phonon (representing intramolecular vibrations). As in the case of the aforedescribed electron-vibrational transitions in luminescence, the band width of two-particle absorption will depend on the width of the exciton band, and the intensity distribution in the former will reflect the level density distribution in the exciton band. The existence of these states in crystals was proved with the aid of the isotope effect. Rashba has developed the theory of two-particle excitations in crystals.

The two reports stimulated lively discussion. Some participants in the seminar supplemented these reports with original communications. **A. N. Faĭdysh** (Kiev State University) spoke on photoconductivity in anthracene crystals within a vacuum and its possible relation to ion-pair states. **O. V. Konstantinov** (Leningrad Physico-technical Institute) spoke about nonlinear effects in exciton absorption that are associated with saturation of the exciton concentration in the case of high light intensity. **V. N. Piskovoĭ** (Kiev Semiconductor Institute) reported about several theoretical studies of exciton states in crystals of finite thickness which were performed at the Semiconductor Institute of the Ukrainian Academy of Sciences. Additional reports on ferromagnetism, ferroelectricity in exciton states, exciton absorption in wurtzite-type crystals, and selection rules for multiphonon transitions to exciton states were presented by representatives of the Institute of Physics of the Moldavian Academy of Sciences at Kishinev (**S. A. Moskalenko, M. I. Shmiglyuk,** and **A. I. Bobrysheva**).

At a business meeting it was decided to organize the seminar on a permanent basis with meetings to take place at least once or twice a year at different scientific centers of the Soviet Union. Academician A. F. Prikhot'ko of the Ukrainian Academy of Sciences was elected chairman of the Organization Committee. The next meeting of the seminar, at Kishinev in September, 1966, will discuss "Exciton Luminescence."

Translated by I. Emin