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Book Reviews

Excitonic Processes in Solids

By M. UETA, H. KANZAKI, K. KOBAYASHI, Y. TOYOZAWA and E. HANAMURA

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[pp. i–xii + 530, with 307 Figures]

An exciton is an electronic excitation wave consisting of an electron interacting with a hole. The excitation can propagate in a nonmetallic solid, and it can interact with other elementary excitations. Many processes involving excitons are important in solid-state physics, particularly in optical phenomena. Therefore, the various dynamical processes of excitons, such as excitation, relaxation, annihilation and molecule formation are being actively investigated.

The present monographs opens with an *Introduction* specifying the shallow and the narrow band excitons. The effective mass approximation is introduced, the role of spin discussed, and the fundamental facts of the optical absorption spectra are stated.

A particular attention is devoted to the dynamical studies on interactions of exciton with photons, phonons and exciton-exciton. Chapter 2 describes the theoretical aspects of excitonic molecule and the electron-hole liquid. Coherent optical phenomena due to the excitonic molecule are described, and the optical bistability due to the excitonic molecule is briefly considered.

Chapter 3 deals, more specifically, with the exciton and excitonic molecule in cuprous halides. Evidence for giant two-photon excitation of the excitonic molecule is presented. Even such phenomena as the acoustic-phonon interaction of the excitonic molecule, rarely mentioned in the literature, are described in Sect. 3.6, in this monograph. Spatial dispersion of the exciton and excitonic molecule is based on good theoretical foundation, with the part of exciton Hamiltonian dependent on the wave vector $\boldsymbol{K}$ written in detail in Sect. 3.10.2.

In Chapter 4 the theory of excitons in phonon fields is developed. The Urbach rule and exciton localization are discussed from an experimental point of view, a detailed account being given to the exciton self-trapping. Self-trapping of an electron, a hole, and of a shallow exciton and a deep one in phonon fields of various types is studied, a particular attention being paid to the roles of force range and dimensionality in the stability and distinguishability of self-trapped state vs free state.

A large Sect. 4.5 entitled *Electron-Hole Recombination* contains qualitative discussion of capture, recombination, and enhanced defect reaction via a deep impurity level in a semiconductor, and a more quantitative consideration of a two-site two-electron system.

Chapter 5 deals with excitons in condensed rare gases, while Chapter 6 is concerned with exciton-phonon processes in silver halides. Section 6.4.3 describes qualitatively the photochemical reactions in silver halides at higher temperatures. The photographic process in silver halides is essentially a photochemical reaction at or near the surface of silver halide grain. The studies of physical processes on the surfaces of silver halide grains require much work to be done.

Chapter 7 reports specific investigations of excitons and their interactions with phonons and external fields in thallous halides. These ionic crystals have many-valley structure both for electrons and holes at a direct forbidden gap. The direct exciton has a unique and complex structure due to intervalley Coulomb and exchange interactions. Spectra of direct as well as indirect excitons have been investigated in detail, particularly in the Japanese laboratories.

Chapter 8 extends the discussions to the photocarrier motion in ionic crystals, where free electron and holes, formed in results of the ionization of excitons, can drift independently in an external electric field, and can also be self-trapped. Polaron and mobility investigations are concisely mentioned, and even magnetoconductivity is well explained.

Chapter 9 entitled *Excitons and Phonon Coupling in Quasi-One-Dimensional Crystals* touches the area which, in the last decade has received a good deal of attention. In quasi-one-dimensional crystals, composed of a boundle of linear molecular chains, the most frequently found excited electronic state is the charge transfer one. In this transfer exciton, an electron in a ground state in one atom is excited to a different atom at a neighbouring site. The radius of the exciton is of the order of the interatomic spacing. A one-dimensional metal is always unstable against electron-phonon or the electron-electron interaction, and, by opening a forbidden energy gap, is transformed into a Peielrs or a Hubbard insulator, respectively. When electron-phonon coupling is dominant a metal becomes a charge-density wave state, and at electron-electron repulsion it becomes a spin-density wave state. Polyacetylene $(CH)_x$, the simplest linear conjugated polymer is an important Peielrs insulator which has been studied extensively by optical means.

Stacked donor-acceptor charge transfer complexes are discussed at the end of this chapter.

As we can see from this brief survey of the contents, the monograph covers a broad area of experimental and theoretical works concerned with the important phenomena of excitons. The publication of this modern book almost coincides with the important results obtained from studies on exciton-exciton interaction with the use of narrowline powerful lasers, and, in particular, from studies on the effect of reduced dimensionality on excitons confined in microfabricated quantum wells in semiconductors prepared by molecular beam epitaxy. Review of the recent achievements in this domain can be found in the *Proceedings of Conferences on Excitonic Optical Nonlinearities* published in J. Opt. Soc. Am. in 1985, and from a conference organized in Japan – in Surface Sci. in 1986.

The monograph *Excitonic Processes in Solids* can serve as an excellent introduction into the practically important and theoretically interesting field of the solid-state physics, the excitons. The treatment is brief and necessitated by a very broad diversity of topics described, but the formulation of basic ideas is clear and easily accessible even for an unexperienced reader. The monograph renders a good service for physicists engaged in the research of excitonic phenomena. Moreover, it can be useful for a more applied-minded researcher who will find here a good introduction to many problems he may encounter in his work. This monograph is a valuable book, in particular for people involved in investigation of the optical properties of solids.

Maciej Suffczyński
Institute of Physics,
Polish Academy of Sciences,
Warszawa, Poland

Laser Optoacoustic Spectroscopy

By V. P. ZHAROV and V. S. LETOKHOV

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The optoacoustic effect, i.e., the formation of acoustic emmission from a medium subjected to transient irradiation with light, was discovered and described by Bell, Tyndall and Roentgen around 1880 and then it remained almost forgotten for a long time. The development of lasers in the sixties and seventies provided the impulse for the development of highly sensitive and versatile spectroscopic techniques based on this effect. The book *Laser Optoacoustic Spectroscopy* by V. P. ZHAROV and V. S. LETOKHOV published by Springer-Verlag is the first extensive review of the subject. The authors tried to incorporate in the book the most up-to-date references providing at the same time all the necessary theoretical background.

A short historical review of the method is given in the *Introduction* and the classification of calorimetric methods of laser spectroscopy is presented. The optoacoustic method is considered to be superior in sensitivity and versatility to the alternate methods of detecting absorption of light, i.e., the optothermal method and the refraction methods. The following three chapters describe the theoretical basis of the optoacoustic spectroscopy of gases and of condensed media as well as the optothermal spectroscopy. Various types of the experimental setups suggested in the literature are considered, their main element being a chamber with the absorbing medium and a microphone for the acoustic pickup. A term "spectrophone" has been coined to describe such a combination.

The designs of spectrophones discussed in the book depend on the type of investigated substances (gases, liquids, solids) and the type of detection (direct or indirect, e.g., in the case of a solid immersed in a liquid). The authors discuss separately non-resonant spectrophones and the cells in which the acoustic waves are in resonance. The description of the experimental equipment is followed by the discussion of the sources of inaccuracies of optoacoustic spectrometers and the limits of their sensitivity.

Part 2 of the book is entitled *Applications* and presents many examples of the use of the optoacoustic techniques. Two chapters deal here with the various applications possible in the spectroscopy of gases and condensed media, respectively. One can use the optoacoustic detection for such diverse tasks as the Doppler-free spectroscopy, multiphoton absorption, Raman spectroscopy, circular dichroism, analysis of surfaces, investigation of photochemical reactions etc. The technical application which seems the most widespread is that of analysis of trace impurities in gases, liquids and solids. As comes from the compiled data of various authors, it is for example possible to detect less than 1 part per billion SO_2 or NO in air!

The optoacoustic effect can also be used in nonspectroscopic applications. An example of such an application is an optoacoustic scanning microscope which is described in one of the chapters. Other applications include the control and stabilization of laser parameters, measurement of thermodynamic parameters, structure of surfaces etc.

The book may be considered to be a rather exhaustive review of the state-of-art in the domain of the optoacoustic spectroscopy and there are numerous references to the original work which may help those readers who want to consult the sources. Since the optoacoustic spectroscopy is gaining more and more popularity as both a research tool and a routine analytical technique, the book may be recommended to a wide range of specialists in spectroscopy as the work of textbook qualities.

The book is generally well written and the presentation of the subject is clear. A few misprints found in the text do not spoil the generally very good opinion about the monograph.

Marek Samoć
Institute of Organic and Physical Chemistry,
Technical University of Wrocław, Wrocław, Poland