PREFACE

The monograph analyzes the results of theoretical investigations of excitons states (electron-hole pairs states) in a quasi-zero-dimensional nanosystems consisting of spherical semiconductor nanocrystals (quantum dots) placed in transparent dielectric matrices. The theory of exciton states in a quantum dot under conditions of dominating polarization interaction of an electron and a hole with a spherical (quantum dot–dielectric matrix) interface are developed. An shown, that the energy spectrum of heavy hole in the valence band quantum dot is equivalent to the spectrum of hole carrying out oscillator vibrations in the adiabatic electron potential. We show that the absorption and emission edge of quantum dots is formed by two transitions of comparable intensity from different hole size–quantization levels and into a lower electron size–quantization level. Propose a theoretical prospect of using hole transitions between equidistant series of quantum levels observed in nanocrystals for desining a nanolaser. The theory of an exciton formed from spatially separated electron and hole (the hole is in the quantum dot volume, and the electron is localized at the outer spherical quantum dot–dielectric matrix interface) is developed within the modified effective mass method. The effect of significantly increasing the exciton binding energy in quantum dots of zinc selenide, synthesized in a borosilicate glass matrix, relative to that in a zinc selenide single crystal is revealed. We developed the theory of a biexcitons (exciton quasimolecules) formed from spatially separated electrons and holes (the hole is in quantum dot volume, and the electron is localized at the outer surface of the quantum dot–dielectric matrix interface) in a nanosystem that consists of zinc selenide quantum dots synthesized in a glassy matrix.

The theory of an exciton formed from spatially separated electron and hole (the hole is in the quantum dot volume, and the electron is localized at the outer spherical quantum dot–dielectric matrix interface) is developed within the modified effective mass method. The effect of significantly increasing the exciton binding energy in quantum dots of zinc selenide, synthesized in a borosilicate glass matrix, relative to that in a zinc selenide single crystal is revealed. It was shown that the short-wavelength shift of the peak of the low-temperature luminescence spectrum of samples containing zinc-selenide quantum dots, observed under the experimental conditions, is caused by quantum confinement of the ground-state energy of the exciton with a spatially separated electron and hole.

A review devoted to the theory of excitonic quasimolecules (biexcitons) (formed of spatially separated electrons and holes) in a nanosystem that consists of ZnSe quantum dots synthesized in a borosilicate glass matrix is developed within the context of the modified effective mass approximation. It is shown that biexciton (exciton quasimolecule) formation is of the threshold character and possible in nanosystem, in with the spacing between the quantum dots surfaces is larger than a certain critical spacing.

The influence of a homogeneous magnetic field on the electron states localized over the surface of an ellipsoidal semiconductor (dielectric) nanoparticle by the electrostatic image forces is studied theoretically. The effects of the resonant interaction of light with such local electron states in presence and in absence of a homogeneous magnetic field are investigated.

In monograph, being based upon the results of our works deals with experimental and theoretical studies of physical characteristics of nanoparticles responsible for specific optical properties of dielectric nanocomposites. During theoretical description and explanation of experimental data obtained, we considered nanoparticle as a multi-particle quantum system of charges which combines elements of quantum structures of a polyatomic molecule and a bulk crystal. Considering nanocomposites with quite a low concentration of nanoparticles (fractions of a percent), we didn't take into account interparticle interaction.

Recently discovered low-threshold nonlinear refraction and absorption of low-intensity laser radiation in dielectric nanostructures is widely described in this chapter. Here we discuss the results of a number of experiments that revealed the nonlinear behaviour of the refractive index and absorption coefficient of continuous low-intensity optical radiation in the Al_2O_3, SiO_2 nanoparticles' array. In addition, we compare the spectral and optical properties of Al_2O_3, SiO_2, TiO_2 and ZnO nanoparticles' array and point out the

conditions to observe the nonlinear optical response. Moreover, the theoretical description of nonlinearity observed is presented. The theory covers the nonlinear transmittance, absorption and scattering of low-intensity radiation in dielectric nanostructures, and suggests that the nonlinearity is of a photo-induced nature.

In summary, this monograph contains a rich selection of important results of the current research in theoretical and experimental optics and spectroscopy of nanosystems, highlighting the great fertility and liveliness of scientific research in the various field of this topic. Many questions raised in this book have practically never been addressed in the monograph literature. In this respect, the authors are confident that this book will be useful as a reference and also contribute to further progress in the study of nanophysics.

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