

Quantum effects in ultracold collisions of atoms, ions, and molecules.

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The doctoral dissertation presents the results of research on the physics of ultracold collisions in systems involving atoms, ions and molecules. The work starts with a historical outline and main results obtained in this field. Then the assumptions of the experiments are presented, which were part of the research work carried out at the stage of preparing the dissertation. In particular, the experiment concerning the first cooling of the mixture of ytterbium ion with lithium atoms to the quantum regime performed in Amsterdam and the results of theoretical research, which guided and confirmed experimental measurement and allowed for the correct interpretation. Moreover, the dissertation presents the path that led to the confirmation of the fact of obtaining ion-atom collisions at a temperature corresponding to the observation of quantum effects, including determination of previously unknown scattering lengths. The second part presents the experiment concerning the first observation of Feshbach resonances in the barium ion system with lithium atoms performed in Freiburg along with the process of estimation the position of resonances, determination of the correct combination of scattering lengths, the number and nature of the observed resonances. Both projects were crucial for the development of the hybrid ion-atom quantum systems and, like in the past, the first cooling of atoms to quantum temperatures opened up a new field of research. The last part presents the analytical calculations of atom-molecule scattering carried out using an anisotropic pseudopotential. The method of an effective potential preserving the mathematical properties of the original interaction was commonly used in the past to the interactions of atoms and allows to gain insight into the nature of the atom-molecule interaction and creates a prerequisite for testing systems with the rotating impurity.