LIGHT-MEDIATED SUPERCONDUCTIVITY

A.V. Kavokin

Spin Optics Laboratory, St-Petersburg State University, 1, Ulianovskaya, St-Petersburg, Russia

We consider theoretically a two dimensional Fermi gas of electrons (2DEG) interacting with a Bose-Einstein condensate (BEC) of excitons or exciton-polaritons. This situation may be realised experimentally if a quantum well (QW) containing a 2DEG is separated by a thin and high potential barrier from QWs containing excitons. There is no overlap of exciton and electron wave-functions, but both types of quasiparticles may efficiently interact if the excitons possess non-zero dipole moments in normal to the QW plane direction. This is the case, in particular, in biased coupled QWs or in QWs with a built-in piezo-electric field. Summing the Feynman diagrams of electron-exciton scattering in the random phase approximation we show that due to scattering between bosons and fermions attractive interactions are induced both in the Fermi sea and in the Bose gas. These interactions have an important effect on the energy spectra of both systems. The dispersion of excitations of the exciton BEC develops a roton minimum. The width of the roton gap may be tuned by changing the barrier thickness between 2DEG and BEC or changing the concentration of excitons. At certain conditions, the energy of the roton minimum may go below the energy of the exciton BEC which manifests the collapse of the condensate and formation of spatially localised exciton droplets. The critical temperature of the Berezinsky-Kosterlitz-Thouless transition in the exciton system decreases in the presence of 2DEG and vanishes at some critical coupling strength [1].

Attractive interactions in the 2DEG induced by coupling with excitons may result in formation of the Cooper pairs and superconductivity. We compute the electron-electron interaction potential and resolve the gap equation by iterations. We show that the strength of Cooper coupling and, as a consequence, the value of superconducting gap and the critical temperature may be tuned in large limits by tuning the exciton concentration by means of resonant optical pumping in microcavities. This effect may pave way to (high temperature) superconductivity in semiconductor heterostructures [2].

Finally, I will discuss the interplay between exciton- and phonon-mediated superconductivity in hybrid semiconductor-superconductor structures and show that a resonant enhancement of the critical temperature for superconductivity may take place in such structures is a certain relation between coupling parameters and Debye temperature is verified.

This work was carried out in the framework of the joint Russian-Greek project supported by Ministry of Education and Science of The Russian Federation **(project RFMEFI61617X0085)**
Работа была выполнена в рамках выполнения совместного Российско-Греческого проекта, поддержанного Министерством Образования и Науки Российской Федерации (проект № RFMEFI61617X0085)

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[2] F.P. Laussy, A.V. Kavokin and I.A. Shelykh, *Phys. Rev. Lett.* **104**, 106402 (2010).