

Many body quantum phenomena in electron-hole ensembles

Makoto Gonokami

(The University of Tokyo, School of Engineering, professor)

【Outline of survey】

Electrons and holes in semiconductors undergo strong Coulomb attraction, forming ensembles in various phases such as exciton gas, electron-hole plasma, electron-hole liquids and exciton condensates. In this project, we perform a systematic and quantitative survey of such phases by a combination of laser spectroscopic experiments and theoretical calculations focusing on the following topics: 1. Search for the phase diagram of electron-hole ensembles including the condition for Bose-Einstein condensation of excitons. 2. Observation of collective excitation of quantum degenerate electron-hole ensembles and their coherence. 3. Theoretical modeling of the dynamics of quantum phase transition of electron-hole ensembles.

【Expected results】

A deeper understanding of carrier correlation effects is an important issue from both fundamental and application points of views. In conventional semiconductor optoelectronic devices such as semiconductor lasers, carrier correlation effects are well reproduced by a mean field approximation. In nanoscale quantum devices, however, we cannot apply the mean field theory. The search for Bose Einstein condensation of excitons has long been a pending question in semiconductor optics. The lack of quantitative information on exciton-exciton interactions, i.e. carrier correlation effects, prevented a systematic understanding of the experimental results. We are planning to reformulate these problems based on a systematic investigation of carrier interactions which will be explored in this project by an experimental and theoretical collaborative study. This may bring us an opportunity to develop new functional devices.

【References by the principal investigator】

- M. Kuwata-Gonokami, M. Kubouchi, R. Shimano, A. Mysyrowicz, "Time-resolved Excitonic Lyman Spectroscopy of Cu_2O ", J. Phys. Soc. Jpn. **73** (4), 1065-1069 (2004).
- M. Kuwata-Gonokami, "Dynamics of cold excitons and electron-hole ensembles in direct-gap semiconductors studied by mid-infrared pump and probe spectroscopy", in "*Problems of Condensed Matter Physics*" Edited by Alexei L. Ivanov and Sergei G. Tikhodeev, Oxford Univ Press, P135-162.

【Term of project】 FY2008 – 2012

【Budget allocation】

115,300,000 yen (direct cost)

【Homepage address】

<http://www.gono.t.u-tokyo.ac.jp>