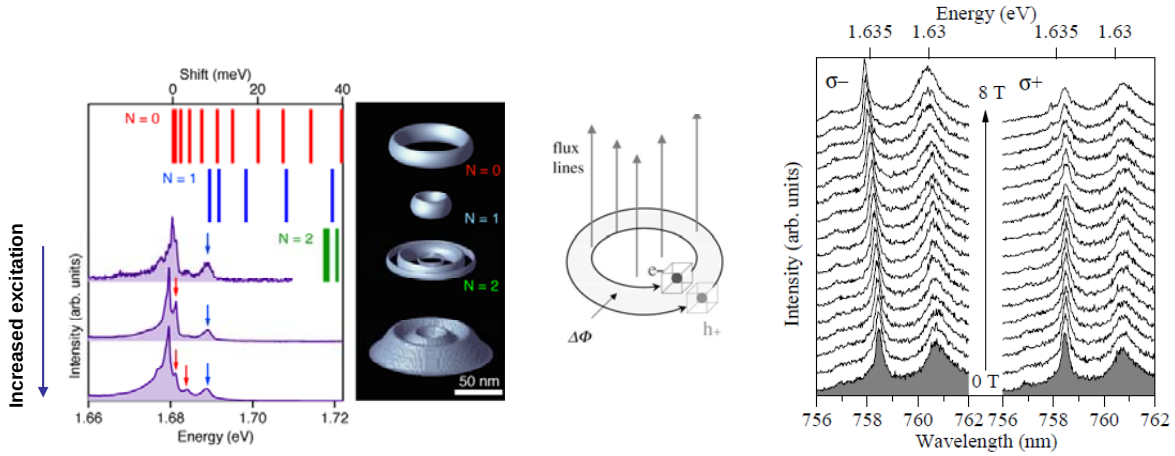
Electronic Levels and Exciton Aharonov–Bohm Effect of GaAs Quantum Double Rings

We previously succeeded in the self–assembly of GaAs quantum double rings by using a weak As flux in the droplet epitaxy （Mano et al., Nano Lett., 2005）. The electronic levels of the quantum double rings are characterized by the principal quantum number N and orbital angular momentum J. As shown in the left panel of the figure, optical transition frequencies calculated by the effective–mass approximation and spectral peaks found by the micro photoluminescence spectroscopy agree with each other well.

If we apply a magnetic field in the direction perpendicular to the ring surface, the phase change of the electron and hole wave functions due to their movement around the rings consists of two terms: one comes from their angular momentum and the other is proportional to the magnetic flux surrounded by their orbital trajectory. Because of the slight difference in the area between the electron and hole trajectories due to the difference in their effective mass and confinement potential (middle panel of the figure), the exciton composed of an electron and hole may posses a phase change proportional to the magnetic field, which is called the exciton Aharonov–Bohm effect, although the exciton is a neutral particle. This effect is important as one of the verification experiments of QED (quantum electrodynamics).

Thus we measured the spectral change of exciton emission in the magnetic field up to 8T by the micro photoluminescence technique. In addition to the spectral shifts in the mutually opposite directions for right– and left–circularly polarized emission components due to the Zeeman splitting, the intensity of the right–circularly polarized component decreases a large amount above 6T (right panel of the figure). This can be explained by crossing of energy levels with different angular momenta caused by the exciton Aharonov–Bohm effect. However, the trion (charged exciton) emission due to unintentional p–doping may show a similar behavior, so we keep investigating carefully.



(Left) electronic levels of quantum double rings (red, blue, and green bars), electron clouds, and emission spectra, (middle) motion of electron and hole in the magnetic field, (right) magneto luminescence spectra. T. Kuroda, et al., physica status solidi (b) **246**, 861 (2009)