Excitonic Fock-Darwin spectrum of a single quantum dot

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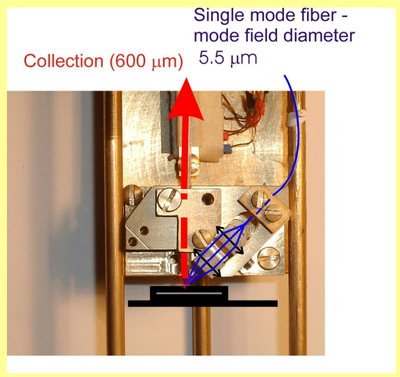
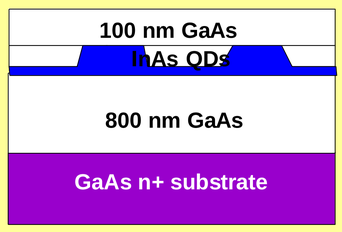
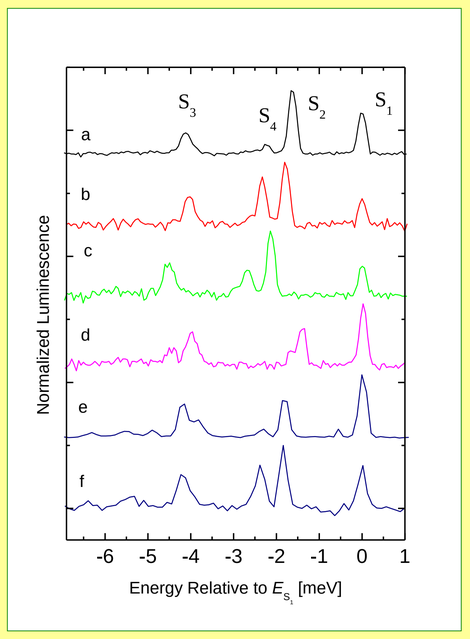
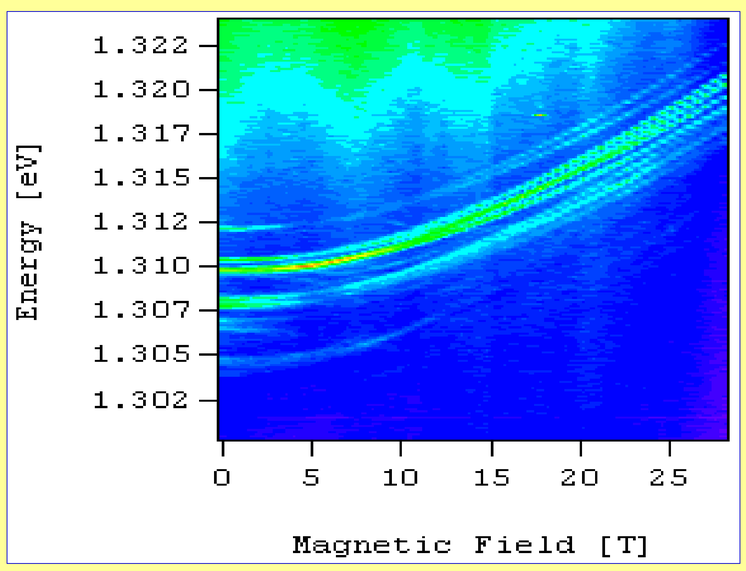
Magnetospectroscopy of a highly excited Single InAs/GaAs Quantum Dot





Single layer of InAs/GaAs
In-flushed* at 5 nm, annealed (850°C for 30 sec.)
***Z.R. Wasilewski et al., J.Cryst.Growth 201/202 (1999) 1131**

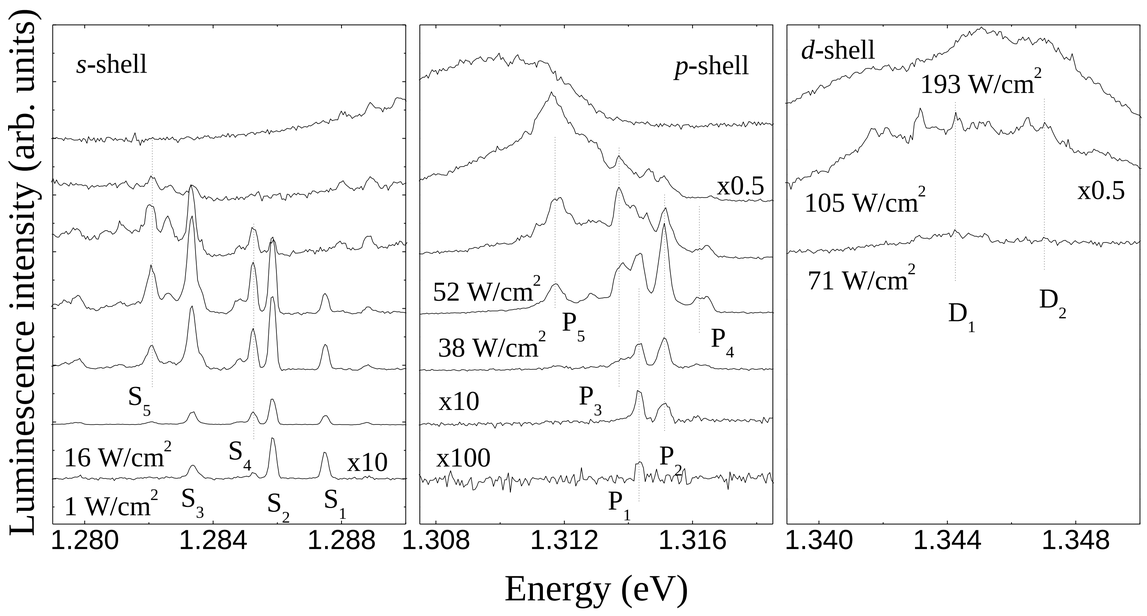




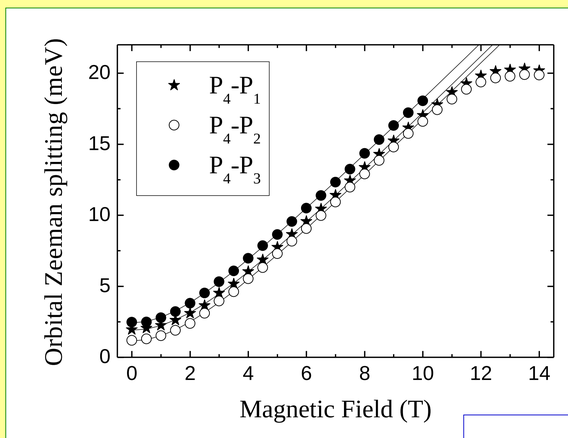
Multiline spectra from a single QD

Typical multiline luminescence (T=4.2K) from the s-shell of a single QD in magnetic field

Measurements are performed at liquid helium temperature.
Investigated sample is *mesa-patterned* to limit the number of investigated dots.
Laser excitation (Ar^+ laser, λ = 514.5 nm) is delivered using a single-mode fiber
and focused onto the sample with two microlenses.
Multimode fiber was used for a luminescence collection.



The „excitonic" F-D diagram must also include ***electron-electron*** interactions and a possible ***asymmetry of localizing potential***

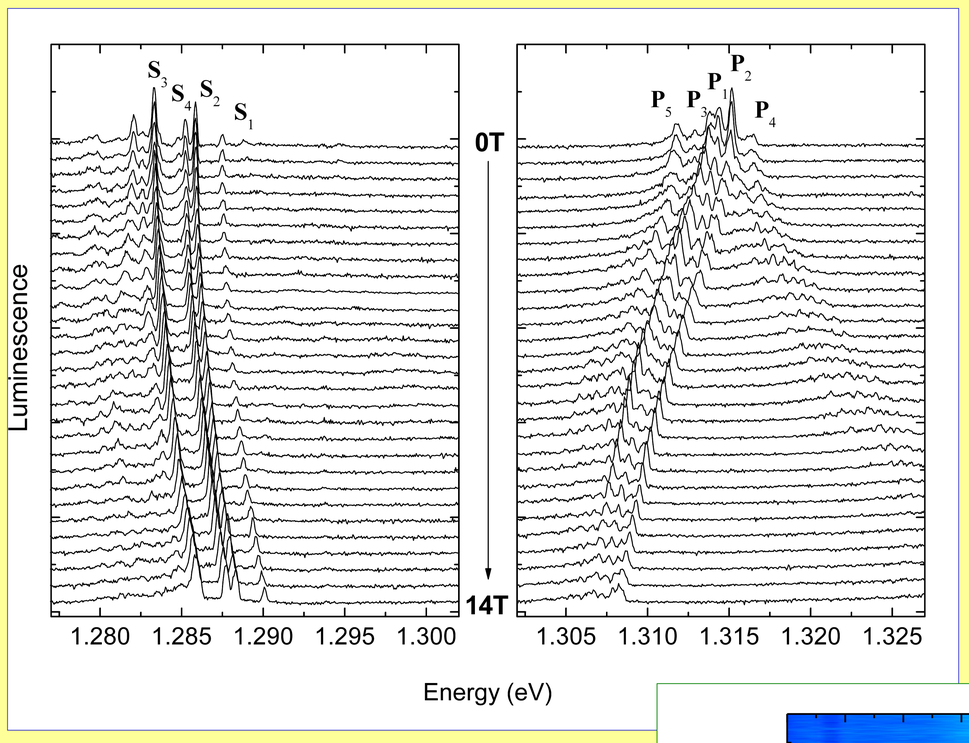


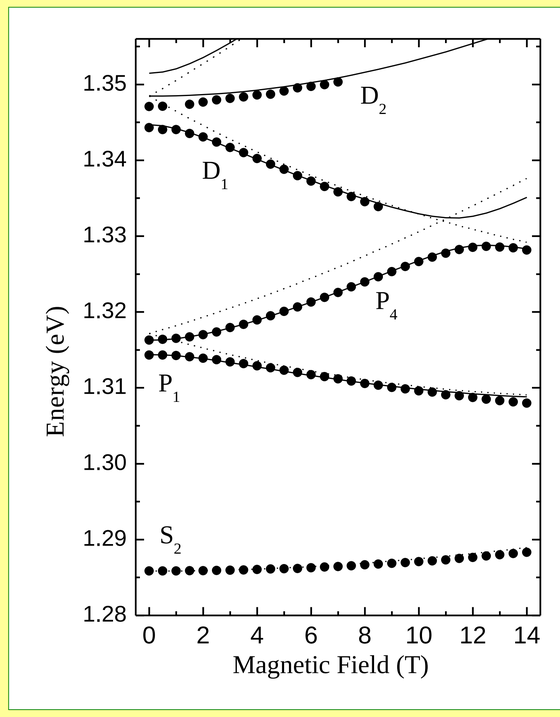
The reduced electron-hole effective mass:
$\mu^* = 0.057 \pm 0.0005\ m_0$,
the zero-field splitting $\delta = 5.5 \pm 0.5$ meV,
the energy E_Δ ranging
from –4.35 meV (P_4-P_2) to –2.6 meV (P_4-P_3).

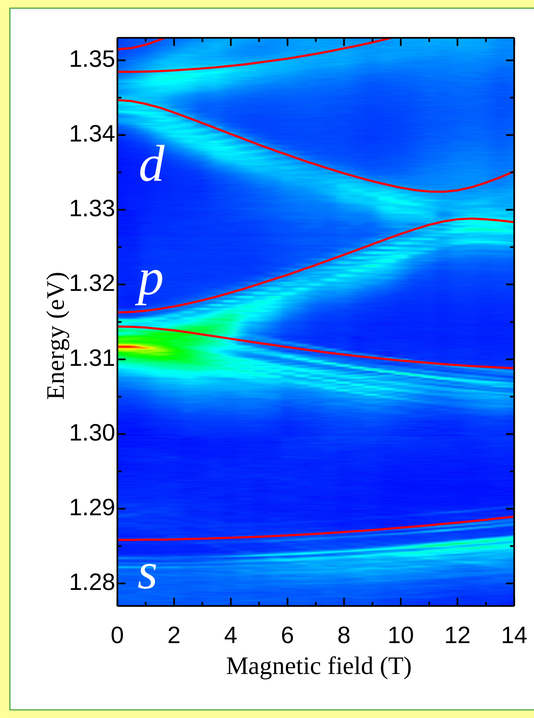
The emission from the *s*-, *p*-, and *d*-shells of a single dot as a function of excitation power at *T*=4.2K in zero magnetic field. The spectra are offset for clarity.

$$\Delta E'(B) = E_\Delta + \sqrt{\delta^2 + (\hbar\varpi_c)^2}$$

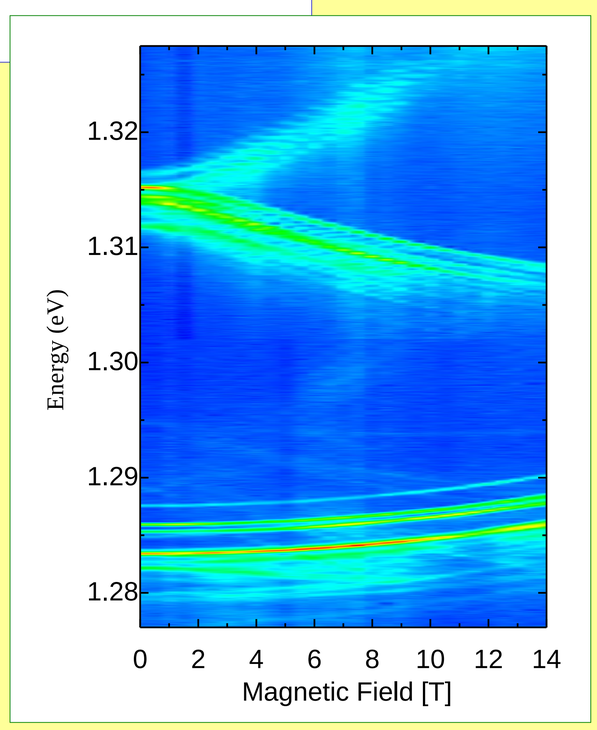
The luminescence from the *s*-shell and *p*-shell of a single QDs in magnetic field.
Excitation power density is approx. 35W/cm^2.







The energy difference ΔE_{nl} between the electronic and hole single-particle levels of the same sets of quantum numbers (which are involved in dipole-allowed optical transitions) can be expressed in terms of an "excitonic" (electron-hole pair) Fock-Darwin diagram



Energies of the S_2, P_1, P_4, D_1 and D_2 emission lines plotted against magnetic field.
Symbols give the experimental data.
Calculated single-particle FD spectrum is shown with dotted lines.
Solid lines - the excitonic FD spectrum
(modified by electron-electron interaction and zero-field splitting)

$$E_{nl}^{\beta} = (2n + |l| + 1)\hbar\Omega_\beta - \frac{1}{2} l\hbar\varpi_c^\beta$$

$$\Omega_\beta = \sqrt{\left(\varpi_0^\beta\right)^2 + \frac{1}{4}\left(\varpi_c^\beta\right)^2}$$

Modified single-particle Fock-Darwin spectrum well describes the emission from a single quantum dot in magnetic field