CFEL SCIENCE

SEMINAR

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CFEL-bldg. 99, seminar room IV (O1.111)

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Quantum-confined semiconductor nanostructures: A boon to modern research

Quantum confinement in semiconductor nanostructures is a phenomenon that leads to the quantization of conduction and valence band. Depending on the type of confinement in the heterostructures, quasi-2D/1D subbands or 0D-sublevels are formed. The spacings between these quantized bands or levels are very important parameters that have been perfected over the years into device applications. Most of these devices form low-dimensional charge-carriers, which potentially allow optical transitions between the subbands or sublevels within the conduction and valence bands in the nanostructures. These transitions typically lie in the infrared region of the electromagnetic spectrum and can be designed according to the application in demand. One of the common examples of a heterostructure where quasi-2Dsubbands are formed is the interface between GaAs and AlGaAs-spacer layers in a high electron mobility transistor (HEMT) structure.

In this talk, I will discuss a method to directly investigate the intersubband spacings of a two-dimensional electron gas (2DEG) formed at this interface via ‘density-chopped’ terahertz transmission spectroscopy. Further, such systems also show the evidence of ultra-strong light-matter interactions between the cavity resonance of a THz meta-material and the intersubband resonance in a single triangular quantum well formed in a HEMT structure. On the other hand, 0D sublevels are formed due to carrier confinement in all three dimensions, an example of which is quantum dots. The optical transitions between such atomically sharp energy levels have been employed to develop devices like lasers and photo-detectors. I will talk about the intersublevel spacings in self-assembled quantum dots. I will also briefly show our work on coupled quantum dot molecules to probe the formation of indirect exciton complexes all-electrically via the capacitance-voltage spectroscopy. In the rest of my talk, I will introduce THz quantum cascade lasers (QCLs) and demonstrate two reversible ways of controlling the mode emission of the laser (viz. narrow-band and double-pulse injection seeding, which are active ways of mode-locking the laser). Finally, I will discuss a way to passively mode lock such lasers using polaritonic systems and its potential application as passive saturable absorbers for the THz QCLs.

Host: Franz Kärtner, CFEL UX Seminar