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IR-ON SEMINAR

Theory of electron dynamics and THz gain in nanowire-based quantum cascade laser

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In terahertz (THz) quantum cascade laser (QCL), fundamental limitations arise from the efficient non-radiative scattering processes that are accompanied with optical phonon emission. As suggested by recent demonstration of long THz excitation lifetimes in self-assembled quantum dots [1], a possible way to circumvent these limitations would be to use an additional lateral confinement, leading to a 3-dimensional quantisation of the electron motion in the device.

Here I will present the theory and simulation of electron transport and optical gain in QCLs made of nanowires with axial superlattice heterostructures. Using the non-equilibrium green function (NEGF) formalism [2], we take into account in a fully quantum way the relevant scattering mechanisms that have been evidenced for either 0-D or 2-D systems. The QCL properties are found to depend dramatically on the nanowire diameter. The lateral confinement allows a new way of controlling the quantum cascade in the growth direction, allowing for lower current threshold, enhanced THz gain, and operation up to higher temperature than in usual planar QCLs.

[1] E. A. Zibik, T. Grange, B. A. Carpenter, N. Porter, R. Ferreira, G. Bastard, D. Stehr, S. Winnerl, M. Helm, H. Y. Liu, M. S. Skolnick, and L. R. Wilson, *Nature Materials* 8, 803 (2009).

[2] T Kubis, C Yeh, P Vogl, A Benz, G Fasching, C Deutsch, *Phys. Rev. B* 79, 195323 (2009).