Seminar announcement

Monday, July 10, 2023
2 pm
WSI, Seminar room S 101

"Coherent frequency combs in mid-infrared and THz produced by self frequency modulated quantum cascade lasers: Linewidth and bandwidth"

For many applications Optical Frequency Combs (OFCs) require a high degree of temporal coherence and thus narrow linewidth as well as wide bandwidth (i.e. many spectral lines). Commonly, OFCs are generated in some nonlinear media from a monochromatic narrow linewidth laser sources or from a mode-locked laser pulses but in the all-important mid-infrared (MIR) and terahertz (THz) regions of spectrum OFCs can be generated intrinsically (i.e. without any intracavity mode-lockers) by the free-running quantum cascade lasers (QCLs) with high efficiency. These combs do not look anything like conventional OFCs as the phases of each mode are different and in temporal domain the OFC is a combination of amplitude- and phase-modulated signals rather than a short pulse. Despite this fact "the experimental evidence suggests that the linewidth of the QCL OFC is just as narrow as that of a QCL operating in the single mode. While universally acknowledged, this observation is not fully understood. In this work we rigorously prove the narrowness of the QCL OFC linewidth by deriving the expression for the Schawlow-Townes linewidth, and furthermore we offer a transparent physical interpretation based on orthogonality of laser modes. Furthermore, we obtain an analytical expression for the maximum potential bandwidth of the frequency modulated comb naturally occurring in free running QCL's. The maximum bandwidth is not as wide as the one attainable in passively mode locked lasers, but wider than that in the actively mode locked ones. The bandwidth is shown to critically depend on the flatness of the gain spectrum and the cavity length and less so on pump current. The results firmly establish that the performance of QCL frequency combs can be on par with combs generated by other means.

Speaker's biography: Jacob B. Khurgin had graduated with MS in Optics from the Institute of Fine Mechanics and Optics (ITMO) in St Petersburg, Russia in 1979. In 1980 he had emigrated to US, and, rather surprisingly, got a job with Philips Laboratories in Briarcliff Manor, NY. There for 8 years he worked with on miniature solid lasers, II-VI semiconductor lasers, various display and lighting fixtures, and small appliances like coffeemakers. Simultaneously, he was pursuing his graduate studies at Polytechnic Institute of NY where he had received PhD in Electro-physics in Jan. 1987. In Jan. 1988 he joined the ECE department of Johns Hopkins University, where he is currently a professor. His research topics over the years comprise an eclectic mixture of diverse subjects, such as optics of semiconductor nanostructures, nonlinear optical devices, semiconductor lasers, optical communications, plasmoncis, metamaterials, laser refrigeration, microwave photonics, opto-mechanics, and more or less fundamental condensed matter physics. He is a fellow of OSA and APS.

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