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Monte Carlo Simulation of Terahertz Quantum Cascade Lasers

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Despite having multitude of potential applications as unique observations of characteristic vibrational and rotational molecular lines, non-ionizing bio-medical imaging, etc. the terahertz frequency range of the electromagnetic spectrum remains comparatively underdeveloped with respect to the nearby microwaves and infrared regions, mainly due to the lack of compact and efficient emission sources. From one side, generation of coherent terahertz radiation involving extension of electronic components to higher frequencies is limited by its internal parasitic roll-offs, from the other, the attempt to extend use of photonic sources to longer wavelengths is constrained by absence of material systems emitting radiation in range of the interest. In this regard, an alternative in the face of recently developed quantum cascade lasers[1,2] seems prospectively attractive. The quantum cascade laser is an example of a device where exploited properties, such as the photon wavelength or population inversion of charge carriers, are not originated from an intrinsic physical attribute of the material, but designed by a judicious adjustment of structure geometry and an appropriate engineering of the wave functions. Thus, fabrication of that type devices demands reliable prior calculations taking into consideration phenomena of quantum nature involved in its operation. One of numerical approaches to solve the standing issue by means of Monte Carlo method will be discussed in the talk.

[1] J. Faist, et al. "Quantum cascade laser"Science, vol. 264, pp. 553–556, April 1994.

[2] R. Kohler, et al. "Terahertz semiconductor-heterostructure laser"Nature,
vol. 41 7, pp. 156–159, May 2002.

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