Investigating the Effects of Resonant Tunnelling in Quantum Cascade Lasers

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Quantum Cascade Lasers are specialized mid-infrared semiconductor lasers that have and continue to demonstrate great potential for research in the fields of health and the environment. Efforts to understand the physics of these devices generally focus on quantum design of the active region, judiciously controlling energy levels and wavefunctions to tailor to a specific wavelength and designing scattering rates and dipole matrix elements to improve optical gain. However, an equally important physical characteristic to the performance of quantum cascade lasers involves transitions of electrons between the lower injector region energy level and the upper active region energy level via resonant tunneling. Understanding of this process and its effect on heterostructure design is of great importance for designing efficient quantum cascade lasers. In this project, I intend to analyze several heterostructures presented by Howard et al. in [1], and, by modelling these structures with variations in barrier thicknesses and the intersubband broadening incurred, as in [2], I intend to investigate the aforementioned effects in quantum cascade laser efficiency and optical gain.

Acknowledgement:

The generous financial support of the MIRTHE REU program made this research possible.

References:

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[2] S. Tsujino, A. Borak, E. Müller, M. Scheinert, C. V. Falub, H. Sigg, and D. Grützmacher. "Interface-roughness-induced broadening of intersubband electroluminescence in p-SiGe and n-GaInAs/AlInAs quantum-cascade structures," *Appl. Phys. Lett.* 86, 062113 (2005).