Physics Seminar

Wednesday, January 29, 2020
132 Oelman Hall 12:20 – 1:15

COOPERATIVE PHENOMENA IN DENSE QUANTUM-DOT ARRAYS*

E.R. Brown and W-D. Zhang
Wright State University Physics Department
elliott.brown@wright.edu ; weidong.zhang@wright.edu

Abstract

Quantum dots have long been a paradigm of nanoscience and are being used worldwide in many fields from condensed-matter physics to biomedicine. Recently we have been studying a type of quantum dot made of crystalline ErAs embedded in GaAs and formed spontaneously by heavy doping concentration of Er (~$4x10^{20}$ cm^{-3}) during MBE growth. The ErAs quantum dots have quasi-spherical diameters in the range 2.0-2.5 nm, a density >$1x10^{18}$ cm^{-3} and a random distribution over a 1 um thick epitaxial layer. At this density the quantum dots are in close enough proximity that cooperative phenomena can be observed. This presentation will cover two such phenomena: (1) cooperative optical spontaneous emission at room temperature when driven by λ = 1550 nm, femtosecond laser pulses; and (2) cooperative electrical transport up to at least 77 K in the form of correlated tunneling (or hopping) between adjacent quantum dots. The first has led to the observation of (Dicke) "superradiance" at THz frequencies, and the second to the discovery of a metal-insulator phase transition (thought to be Mott type), along with giant magnetoresistance in the metallic state.

*This research was supported primarily by the U.S. Army Research Office (Dr. Joe Qiu), and to a lesser extent by the Air Force Research Laboratory (Dr. Rob Ewing)