PHYSICS AND ASTRONOMY COLLOQUIUM

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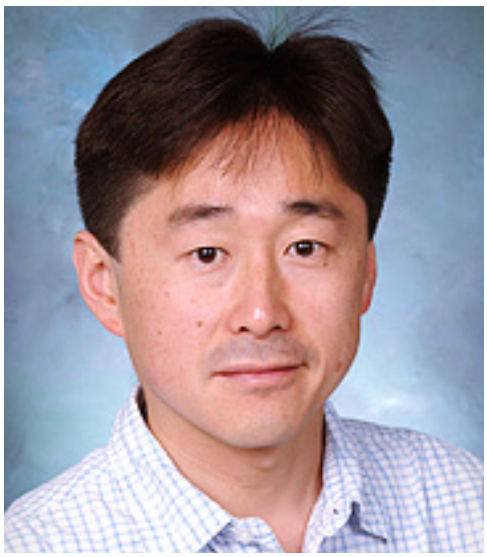
Spontaneous Appearance of Coherence in Quantum-Degenerate Electron-Hole Gases



Since the pioneering theoretical work by Mott, Blatt, Knox, Keldysh, and Kopaev nearly 50 years ago, a large body of work has been devoted to many-body effects in electron-hole (e-h) systems in semiconductors. A fascinating array of possible physical phenomena and states have been predicted for e-h systems, including Bose-Einstein condensation, the excitonic insulator, a gas-liquid-type phase transition, and superfluidity. Here, we demonstrate spontaneous appearance of coherence in a 2D e-h system in high magnetic fields [1-4]. We create a dense e-h plasma with an intense laser pulse, and after a certain delay, a picosecond burst of coherent radiation emerges. We interpret this striking phenomenon as superfluorescence (SF), in which a macroscopic polarization spontaneously builds up from an initially incoherent ensemble of excited quantum oscillators and then decays abruptly, producing giant pulses of coherent radiation. SF has been observed in atomic gases, but the present work represents the first observation of SF in a semiconductor, where not only real-photon exchange but also virtual-photon exchange (Coulomb interactions) is responsible for the formation of macroscopic coherence. This Coulomb enhancement allows the magnitude of the macroscopic dipole to exceed even the maximum possible value for ordinary SF, making e-h SF even more “super” than atomic SF.

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