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Experimental Tests of Supradegeneracy and the Second Law of Thermodynamics

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Most thermodynamic systems live and die by the Boltzmann exponential; the standard occupation functions (Fermi-Dirac, Bose-Einstein, and Boltzmann) are defined by it. In discrete energy systems, state degeneracy is usually of secondary importance, while in continuous energy systems, density of states functions may dominate the Boltzmann factor at low energies but never at high. However, this need not be the case.

Recently, a new type of degeneracy (supradegeneracy) has been proposed in which state degeneracy increases more quickly with energy than the Boltzmann exponential, thereby dominating it at high energies. The result are systems that display a form of population inversion at thermal equilibrium without the need for non-equilibrium pumping. No naturally occurring supradegenerate systems appear to exist; however, analysis indicates man-made supradegenerate systems should be constructable. Some are predicted to have remarkable properties, including allowing tests of the limits to the second law of thermodynamics.

In this presentation, the essentials of supradegeneracy will be reviewed and second law tests proposed. Laboratory experiments (currently in progress) will be described in which supradegeneracy is being investigated. These involve silicon that is differentially doped with p-type impurities near its valence band edge, forming a suprathermal "energy ladder" up into the band gap. It is predicted that electrons can climb the ladder to suprathermal energy states (E » kT) driven solely by thermal energy from the lattice. Should these silicon experiments demonstrate the effect, efforts will be made to build energy ladders across the entirety of narrow-gap semiconductors. This should allow new and sensitive tests of the absolute status of the second law.

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