WEEKLY S E M I N A R

Wednesday 04/03/20, 11:00 am

Building 211, seminar room

SPEAKER:

Prof. Carmel Rotschild

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TOPIC:

Photoluminescence: from new fundamentals to new solar technology

Abstract:

The radiance of thermal emission, as described by Planck's law, depends only on the emissivity and temperature of a body, and increases monotonically with temperature rise at any emitted wavelength. Nonthermal radiation, such as photoluminescence (PL), Electroluminescence (EL), or Chemiluminescence (CL) is a fundamental light-matter quantum process governed by a rate equation. PL, as an example, conventionally involves the absorption of an energetic photon, thermalization, and the emission of a red-shifted photon. Until recently, the role of the rate conservation when the thermal excitation is significant has not been studied in any nonthermal radiation. Naturally, this left many questions open. For example, what is the overall emission rate if a high quantum efficiency (*QE*) PL material is heated to a temperature where it thermally emits a rate of 100photons/sec at its band edge, while the PL is simultaneously being excited at a rate of 100 photons/sec? Our group has discovered that the answer is an overall rate of 100 blue-shifted photons/sec. In contrast to thermal emission, we experimentally observed that the PL rate is conserved if the temperature increases, while each photon is blue-shifted (photon-energy increased). This results in a reduction in rate of the low energy photons with temperature. A further rise in temperature leads to an abrupt transition to thermal emission where the photon rate increases sharply at any wavelength. **Thus far there was no theoretical explanation for these experimental observations**. Recently, we solved this challenge by including phononic spontaneous and

stimulated interactions into a detailed balance analysis. The unique solution of the model explains for the first time our recent experimental evidence and predict many new and important discoveries including **i)** A universal point defined by the pump rate and the temperature where the emission is fixed to system independent on the *QE*. **ii)** inherent dependency between emissivity and *QE*. We take this new understanding and build a solar energy device, where photoluminescence absorbs solar radiation and emit red-shifted photons, driving a solar cell at its band-edge nearly as efficient as under direct illumination. The thermalization as part of the photoluminescent, increase the temperature to 550C. This otherwise wasted heat can be stored for the night and drive a turbine at 40% efficiency, offering a solar baseload solution.