Solid State Institute
המכון למצב מוצק

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מכון טכנולוגי לישראל

SPECIAL SEMINAR **סמינר מיוחד**

Bright triplet excitons in cesium lead halide perovskites

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Abstract

The observation of a ground optically forbidden "dark" exciton state in semiconductor nanocrystals was first reported in the seminal paper of Nirmal et al. in 1995. [1] Later research in nanowires, nanorods, and nanoplatelets has shown that the ground exciton state in all these semiconductor structures is a dark exciton, leading us to believe that the ground exciton must be dark. Because dark excitons release photons slowly, hindering emission, semiconductor nanostructures that disobey this rule have been sought. However, despite considerable experimental and theoretical efforts, no semiconductors have been identified in which the lowest exciton is bright. Three years ago however cesium lead halide perovskite (CsPbX3, with X = Cl, Br or I) nanocrystals were grown, which without too much effort, demonstrated very bright photoluminescence (PL) with quantum yield 50-90% at room temperature. This bright emission was traced to a very short radiative decay time. The nanocrystals emit light about 20 and 1,000 times faster than any other semiconductor nanocrystal at room and cryogenic temperatures, respectively. The increase of the decay time with temperature is inconsistent with a dark ground state exciton suggesting that in these nanocrystals the ground exciton state is bright. We use an effective-mass model and group theory to demonstrate the possibility of such a ground bright state existing, which can occur when the strong spin–orbit coupling in the conduction band of perovskites is combined with the Rashba effect.[2] We then apply our model to CsPbX3 nanocrystals, and measure size- and composition- dependent fluorescence at the single-nanocrystal level. The bright triplet character of the lowest exciton explains the anomalous photon-emission rates of these materials. The existence of this bright triplet exciton is further confirmed by analysis of the fine structure in low-temperature fluorescence spectra. More generally, our results provide criteria for identifying other semiconductors that exhibit bright excitons, with potential implications for optoelectronic devices.

[1]Nirmal, M. et al. "Observation of the "dark exciton" in CdSe quantum dots." *Phys. Rev. Lett*. **75**, 3728–3731 (1995).
[2] Becker, M. A. "Bright triplet excitons in caesium lead halide perovskites," *Nature*, **553**, 189-193 (2018).

ההרצאה תתקיים ביום חמישי, ה-2.5.19 בשעה 12:30
באודיטוריום המכון למצב מוצק, קומת כניסה
The lecture will take place on Thursday, 2.5.19 at 12:30
at the Solid State Institute auditorium, entrance floor

Host: Professor Efrat Lifshitz