SUPER-QUADRATIC BEHAVIOR OF LUMINESCENCE DECAY EXCITED BY ENERGY-TRANSFER UPCONVERSION

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For several decades, energy-transfer upconversion (ETU) in rare-earth-ion doped systems [1,2] has attracted much attention, firstly, because of the fundamental interest in the physical nature of this process and, secondly, because of very practical considerations, namely the demonstration of near-infrared pumped visible light sources and, in reverse, the detrimental influence of ETU on the efficiency of infrared emitting systems.

We investigate fundamentally the behavior of infrared luminescence emitted directly from a metastable level and visible luminescence emitted after ETU from this level to higher-lying levels. Although these two luminescences are connected by the same metastable level and influenced by the same ETU process, the infrared luminescence probes all ions, while the visible luminescence probes only the class of ions susceptible to ETU [3]. A simple analytical model [4] predicts that such luminescence decay curves exhibit a super-quadratic dependence of upconversion on direct luminescence decay.

The Nd^{3+} ion can serve as a model system for such investigations. It exhibits strong ETU from the metastable $^4F_{3/2}$ level. When doped into oxide matrices, the $^4F_{3/2}$ level is the only metastable level. The Nd^{3+} energy levels excited by ETU decay by fast multiphonon relaxation and, hence, the weak visible fluorescence emitted from these levels represents a quasi instantaneous reaction on the dynamics of the $^4F_{3/2}$ level. Experimental results obtained after pulsed laser excitation of Nd^{3+}-doped oxide host materials show indeed a super-quadratic behavior of upconversion versus direct luminescence decay, in accordance with the model predictions [4].

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