Anomalous optical properties of $LaPO_4:Pr^{3+}$ at low temperatures

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We have studied the optical properties of Pr^{3+} doped $LaPO_4$ (LAP). This system has the intriguing feature of emitting from both $^1S_0$ and 5d states at low temperatures, with the energy of the $^1S_0$ state being situated below that of the 5d zero phonon level. Moreover, the Pr^{3+} 5d emission bands remain intense even at very low temperatures (T < 2K, Fig. 1), indicating that the 5d and $^1S_0$ states do not reach a thermal quasi equilibrium within the timescale of the 5d relaxation (~10^{-8}s).
Comprehensive spectroscopic studies, including emission, photoexcitation, and time-resolved fluorescence as a function of temperature between 1.6 K and 300 K, were performed to determine the static and transient features of the system (Fig. 2), including level separation, the relaxation rates of the 4f and 5d states, and the coupling between the $^1S_0$ and the lowest 5d level.

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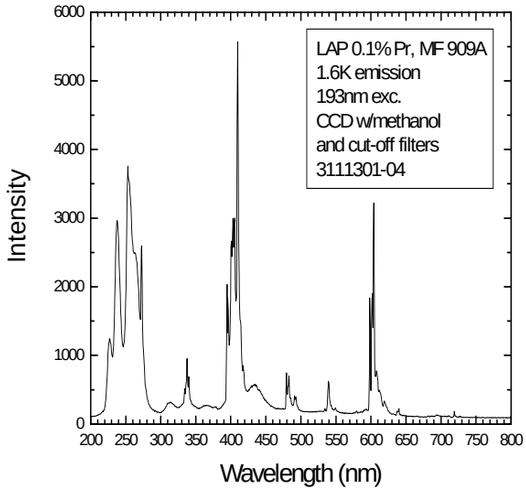

Fig. 1: Emission spectrum of LAP:Pr^{3+} showing both sharp f-f transition superimposed on broad 5d -> 4f emission bands.

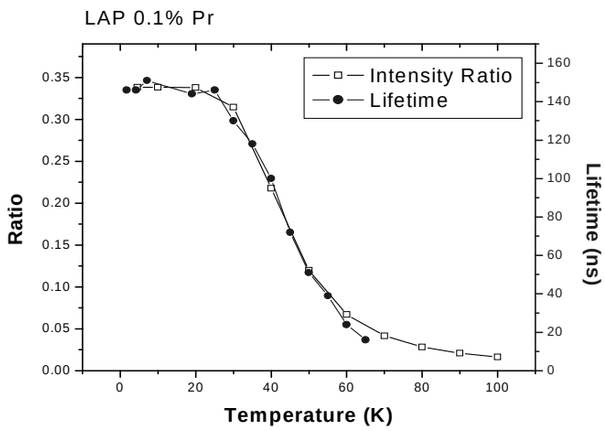

Fig. 2: Comparison of the temperature dependence of the $^1S_0$ relaxation time (solids dots, right hand scale) and the ratio of the $^1S_0$ to the 5d emission intensity (open squares, left hand scale).