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Random lattice deformations in rare-earth-doped cubic hexafluoroelpasolites: High-resolution optical spectroscopy and theoretical studies

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Abstract

High-resolution Fourier spectroscopy is used to study the low-temperature (3-10 K) optical absorption spectra of Cs₂NaYF₆ and Cs₂NaScF₆ crystals doped with rare-earth ions, which substitute for Y³⁺ or Sc³⁺ ions at sites with cubic Oh symmetry. Splitting of some absorption lines corresponding to doublet (Γ_6 or Γ_7)-quadruplet (Γ_8) transitions in the Kramers Yb³⁺, Er³⁺, and Sm³⁺ ions and a singlet (Γ_1)-triplet (Γ_4) transition in the non-Kramers Tm³⁺ ion is observed. In the vicinity of these lines, additional spectral satellites with intensities depending nonlinearly on the concentration of the rare-earth ions are present. We argue that the observed splitting is caused by low-symmetry components of the crystal field induced by random lattice strains. An explicit expression for the generalized distribution function of local strains produced by random point defects in the elastic continuum is derived and used to simulate the line shapes. A satisfactory agreement with the measured spectra is achieved. The observed satellite transitions are ascribed to pairs of the nearest-neighbor rare-earth ions interacting through the dynamic lattice deformations. © 2012 American Physical Society.

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