TRANSITION INTENSITIES OF TRIVALENT LANTHANIDE IONS IN SOLIDS: EXTENSION OF JUDD-OFELT THEORY ON Eu^{3+}, Nd^{3+} AND Er^{3+}

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Lanthanides are widely used in the industry. For example, they are used as the active ions in luminescent materials used in optoelectronics applications, most notably the Nd:YAG laser. Erbium-doped fiber amplifiers are significant devices in optical-fiber communication systems. These and other applications are based on optical transitions between levels of the ground configuration of the trivalent lanthanide ions. Being forbidden in the electric-dipole approximation, those transitions are activated by the crystal-field potential created by the host material. The Judd-Ofelt (JO) theory has been successfully applied since 60 years, to interpret the intensities of absorption and emissions lines of crystals and glasses doped with trivalent lanthanide ions. Despite the fact that it is remarkably efficient for many cases, the standard version of the JO theory cannot reproduce some of the observed transitions, because of its strong selection rules [1,2].

In order to overcome this issue we present a modified version of the JO theory, where the properties of the dopant are calculated with well-established atomic-structure techniques, while the influence of the crystal-field potential is described as a perturbation, by three adjustable parameters [3]. In the extension we introduce also the wavelength-dependence of the refractive index of the host material with the help of the Sellmeier equation. We test the validity of our model on three ions: Eu^{3+}, Nd^{3+} and Er^{3+}. The results of the extension are very good. We are able to give a physical insight into all the transitions within the ground electronic configuration, and also to reproduce quantitatively experimental absorption oscillator strengths.

[1] doi:10.1103/PhysRev.127.750, B. R. Judd, *Phys. Rev.*, **127**, 750 (1962).

[2] doi:10.1063/1.1701366, G. S. Ofelt, *The J. of Chem. Phys.*, **37**, 511–520 (1962).

[3] doi:10.1016/j.jlumin.2021.118456, G. Hovhannesyan, V. Boudon, M. Lepers, *J. Lumin.*, **241**, 118456 (2022).