POLARIZED EMISSION SPECTRA OF TRIVALENT EUROPIUM IN GADOLINIUM ALUMINIUM BORATE

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The $^5D_0-^7F_2$ emission lines of $GdAl_3B_4O_{12}-Eu^{3+}$ do not follow the selection rules for electrical dipole emission. This is interpreted as evidence for pseudoquadrupole transitions.

A number of years ago the emission spectrum of Eu^{3+} in the hexagonal lanthanide aluminium borates $LnAl_3B_4O_{12}$ has been reported for powder samples [1]. The Eu^{3+} ion is surrounded by a trigonal prism of oxygen anions and its site symmetry is D_3 [2]. The main emission consists of two $^5D_0-^7F_1$ and two $^5D_0-^7F_2$ lines. In view of a suggestion made by Jørgensen and Judd [3] that transitions with $\Delta J = \pm 2$ may be pseudoquadrupole transitions and as such hypersensitive to their surroundings, it seemed interesting to study the polarization of these lines especially to see whether the $^5D_0-^7F_2$ emission behaves as a (forced) electric dipole transition or not.

For this purpose we investigated $GdAl_3B_4O_{12}-Eu^{3+}$ (3%) crystals (size a few mm in all dimensions) with a very simple and inexpensive apparatus designed by one of us [4]. The excitation is with blue radiation. The measurements were performed at room temperature. The experimental results are given in table 1.

From these data it is clear that the $^5D_0-^7F_1$ emission is strongly polarized, whereas the $^5D_0-^7F_2$ emission is not.

The $^5D_0-^7F_1$ emission of Eu^{3+} is mainly magnetic dipole emission [1,5]. Under D_3 symmetry the $J = 1$ level splits into a doublet $A_2 + E$, so that the polarization behaviour is not unexpected. The 591.7 nm line is the transition to the A_2 component, the 596.0 nm line the one to the E component.

Table 1
Emission spectrum of $GdAl_3B_4O_{12}-Eu^{3+}$ (3%) crystals

Transition	Peak wavelength (nm)	Estimated intensity (linear)	Polarization [a]
$^5D_0-^7F_1$	591.7	4	⊥
		2	∥
	596.0	1	⊥
		2.5	∥
$^5D_0-^7F_2$	613.6	9	⊥
		10	∥
	618.2	4.5	⊥
		5	∥

[a] The polarization characteristics of the radiation relative to the unique axis are expressed in terms of the plane of the electric vector.

The $^5D_0-^7F_2$ emission may be forced electric dipole emission [5] or pseudoquadrupole emission [3]. The $^7F_2$ state splits into $A_1 + 2E$ under D_3 symmetry. For dipole emission only the two transitions $^5D_0-^7F_2(E)$ are expected with polarization ⊥. Our experimental results contradict this expectation.

For quadrupole emission, however, three emission lines are expected. In addition we expect also polarization for pure quadrupole transitions.

The only way out of this is to assume that the $^5D_0-^7F_2$ transitions are pseudoquadrupole transitions. The five components of the electric quadrupole tensor are not necessarily equal to the five components at the europium nucleus, so that agreement for the polarization behaviour is not required [3]. In addition one of the three possible $^5D_0-^7F_2$ transitions must either have a low intensity or practically coincide with an other.

Finally we note that in other compounds the polarization behaviour of the $^5D_0-^7F_2$ transition is as is to be expected for electric-dipole transitions (YPO_4–Eu, YVO_4–Eu [6]), but that in a scheelite mineral of Tecoripa, studied previously by one of us [4], the $^5D_0-^7F_1$ emission is polarized as expected for magnetic dipole emission, whereas the $^5D_0-^7F_2$ emission shows no polarization in contradiction with the expectation for electric dipole emission.

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