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PHYSICS

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Abstract

Full Text

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PHYSICS

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ON THE INCREASE IN SYMMETRY OF THE LUMINESCENCE CENTER OF EUROPIUM BENZOYLACETONATE UNDER THE INFLUENCE OF HYDROSTATIC COMPRESSION

Under hydrostatic compression, the additional energy may be expended either on increasing the absolute value of the lattice potential, which will affect the magnitude of the crystal splitting of individual levels, or on changing the symmetry, in which case the mutual arrangement of the components of the splitting of this level will change, up to a change in their number.

In the present work, polycrystalline europium benzoylacetonate was investigated. The center of the molecules of this compound is the europium ion, whose luminescence spectra are determined by the configuration $4f^6$. The nearest environment consists of 6 oxygen atoms. The symmetry of the field in which the europium ion is located is conveniently judged from the lines of the transition $^5D_0 \rightarrow {}^7F_1$. (All three components have approximately the same intensity and lie in such a spectral region where the intensity of the lines corresponding to transitions from $^5D_1$ is much lower.)

Depending on the synthesis, the symmetry and the strength of the field in which the europium ion is located are different. In one case, the total splitting of the $^7F_1$ level reaches 250 cm^{-1}, and the middle of the three components is equally spaced from the outer ones. In this case the symmetry is very low (triclinic or monoclinic). In the case under study, the magnitude of the splitting of the $^7F_1$ level is two times smaller, (116 ± 3) cm^{-1}, and although the number of components remains the same (3), their arrangement is asymmetric. In this case the symmetry formally remains the same—triclinic or monoclinic—but it may be assumed that the magnitude of the splitting is determined no longer by the quadratic terms in the expansion of the potential, but by terms of the fourth degree. In other words, it is assumed that the nearest environment—6 oxygen atoms—forms a regular octahedron, while the deviation from cubic symmetry is caused by the influence of the second sphere (mainly the groups $-CH_3$ and $-C_6H_5$), which is more accessible to external influences than the first.

Polycrystalline europium benzoylacetonate, characterized by the spectrum

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Fig. 1. Change in the splitting pattern of the $^7F_1$ level upon increasing and subsequently decreasing the pressure

Figure 1: Fig. 1. Change in the splitting pattern of the $^7F_1$ level upon increasing and subsequently decreasing the pressure

shown in Fig. 1 (0 kbar), was successively subjected to pressure up to 10 kbar. An increase in the asymmetry of the splitting pattern was observed, ending in the practically complete merging of two components (Fig. 1). As is known, splitting of a level with $J = 1$ into 2 components already corresponds to higher symmetry (of the tetragonal-hexagonal type). The magnitude of the total splitting of the $^7F_1$ level, however, practically did not change (the accuracy of determining the positions of the lines, owing to their broadening, was ~ 3 cm^{-1}). This indicates that the first portions of additional energy obtained by the system under hydrostatic compression went not into increasing the field strength, but into increasing the symmetry. It should be noted, however, that the observed process is reversible. This indicates that the absolute value of the energy corresponding to the equilibrium position under hydrostatic compression is greater than the corresponding value under normal conditions.

It may be assumed that, because of asymmetry in the chemical structure of the molecule, strict cubic symmetry cannot be created within the range of sufficiently low pressures, and therefore a subsequent increase in pressure should lead to an increase in the magnitude of the total splitting of the $^7F_1$ level. Otherwise all components of the splitting should merge into one triply degenerate line.

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Note: Figure translations are in progress. See original paper for figures.

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