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Constant of Verde of aluminium-rare-earth garnets

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The model of local optical dipoles [1] for an explanation of the nature of dependence of a constant of Verde of aluminium-rare-earth granates from the magnetic moment of an ion of rare-earth element $m_B gJ$ (m_B-magneton of Bohr, g and J – the factor of Lande and the angular moment of a 4f-shells, accordingly) is considered. Research has shown that Faraday rotation in the aluminium-rare-earth garnets $R_3Al_5O_{12}$ (R=Tb, Dy, Ho, Er, Tm, Yb) [4] is caused, as well as electric polarizability RIG [3], the local magnetic fields created by 4f-shellss of rare-earth elements (type interaction «spin-another's an orbit») and operating, in essence, within nuclear radius of rare-earth elements.

Keywords: 4f-shellss, local optical dipoles, a constant of Verde, a magnetic susceptibility.

Рассмотрена модель локальных оптических диполей [1] для объяснения природы зависимости константы Верде алюмо-редкоземельных гранатов от магнитного момента иона редкоземельного элемента $m_B gJ$ (m_B –магнетон Бора, g и J – фактор Ланде и угловой момент 4f-оболочки, соответственно). Исследование показало, что фарадеевское вращение в алюмо-редкоземельных гранатах $R_3Al_5O_{12}$ (R=Tb, Dy, Ho, Er, Tm, Yb) [4] обусловлено, как и электрическая поляризуемость RIG [3], локальными магнитными полями, создаваемыми 4f-оболочками редкоземельных элементов (взаимодействие типа «спин-чужая орбита») и действующими, по существу, в пределах атомного радиуса редкоземельных элементов.

Ключевые слова: 4f-оболочки, локальные оптические диполи, константа Верде, магнитная восприимчивость.

Розглянута модель локальних оптичних диполів [1] для пояснення природи залежності константи Верде алюмо-рідкоземельних гранатів від магнітного моменту іона рідкоземельного елементу $m_B gJ$ (m_B -магнетон Бору, g і J - фактор Ланде і кутовий момент 4f-оболонки, відповідно). Дослідження показало, що фарадеєвське обертання в алюмо- рідкоземельних гранатах $R_3Al_5O_{12}$ (R=Tb, Dy, Ho, Er, Tm, Yb)[4] обумовлено, як і електрична поляризуємість RIG [3], локальними магнітними полями, що створюються 4f-оболонками рідкоземельних елементів (взаємодія типу «спін-чужа орбіта») і діючими, по суті, в межах атомного радіусу рідкоземельних елементів.

Ключові слова: 4f-оболонки, локальні оптичні диполі, константа Верде, магнітна сприйнятливість.

Introduction

Rare-earth elements (REE) are the fundamental constituent of many compounds used in construction materials of modern electronics, in particular in magnetooptics (MO) devices. In this connection there is of interest finding out of mechanisms of forming of MO of properties of REE.

In the real work we develop the model of local optical dipoles [1], used for explaining to of nature dependence of electric polarizability of rare-earth ferrits-garnets (RIG) [2] from the magnetic moment of ion of REE $m_B gJ$ (m_B - magneton of Bohr, g and J is a factor of Lande and angular moment of 4*f*- shells, accordingly) [3]. Research showed that a Faraday rotation is in the aluminium-rare-earth garnets $R_3Al_5O_{12}$ (R=Tb, Dy, Ho, Er, Tm, Yb) [4] it contingently, as well as electric polarizability of RIG [3], by the local magnetic fields created by the 4*f*- shellss of REE (type interaction «spin-another's an orbit») and operating, essentially, within the limits of atomic radius of REE.

Model and experiment

In our model (in fundamental part consilient with a model [3]) expression for the constant of Verde $V(\nu,T)$ at $H\to 0$, looks like :

$$V(\nu,T) = a(T)g(J+1)\times \times(b-gJ)\frac{\nu^2 E_{if}}{\left(E_{if}^2-\nu^2\right)^2} , \qquad (1)$$

where ν - energy of photon; E_{if} - energy of resonant optical transition; *T*- temperature; $a(T)$ - function, proportional to magnetic receptivity and containing rate fixing constants different, as follows from an experiment, for Tb and Dy, from one side, and for Ho, Er, Tm and Yb, with other (Fig. 1.).

Taking into account the rate fixing constants of REE expression for the constant of Verde *V* (1) as a function of energy of photon of *E* looks like

$$V_R(E) = a_R\frac{E^2 E_{ifR}}{\left(E_{ifR}{}^2-E^2\right)^2} . \qquad (2)$$

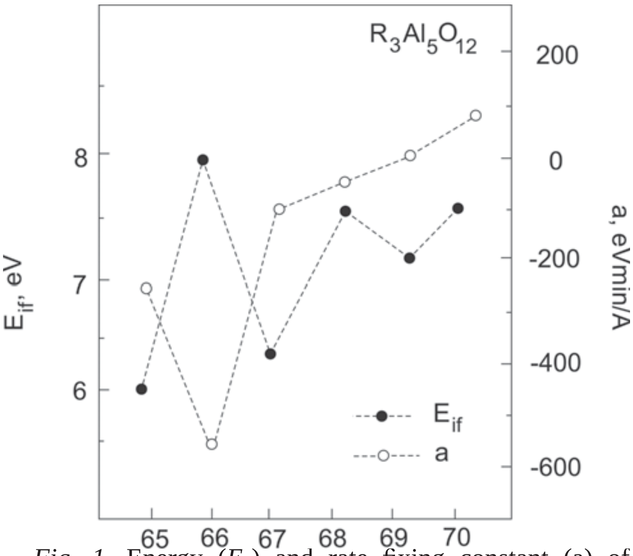

Fig. 1. Energy (E_{if}) and rate fixing constant (a) of resonant optical transition are in the aluminium-rare-earth garnets, got within the framework of the real model with the use of data [4].

On Fig. 2. dependence of constant of Verde is shown on energy of photon.

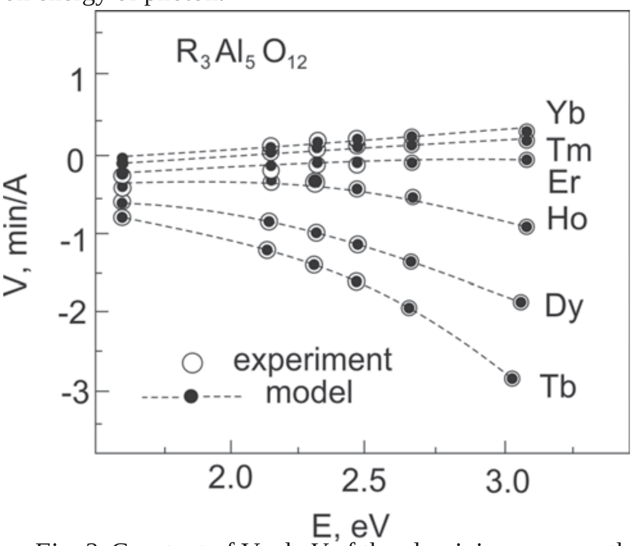

Fig. 2. Constant of Verde *V* of the aluminium-rare-earth garnets of $R_3Al_5O_{12}$, as a function of energy of photon of E; experimental values - from data [4], model is adjustment for the model developed in this work.

Constant of Verde, as function of atomic number of rare-earth element of Z got with the use of fitting parameters of *b*=7.6, *a*(*T*)=2.4 eVmin/A for Tb and Dy, and *a*(*T*)=0.6 eVmin /A for Ho, Er, Tm and Yb, at ν=3.06 eV and *T*=300 K:

$$V(3.06\ \text{eV}, 300K) =$$

$$= 2.4g(J+1)(7.6-gJ)\frac{3.06^2 E_{if}}{(E_{if}{}^2 - 3.06^2)^2} \quad (3)$$

for Tb и Dy, and

$$V(3.06\ \text{eV},\ 300K) =$$

$$= 0.6g(J+1)(7.6-gJ)\frac{3.06^2 E_{if}}{(E_{if}{}^2 - 3.06^2)^2} \quad (4)$$

for Ho, Er, Tm and Yb.

On Fig. 3. dependence of constant of Verde is presented on the atomic number of rare-earth element from which evidently, that a model provides adjustment of the experimentally looked after size of constant of Verde V rare-earth garnets [4].

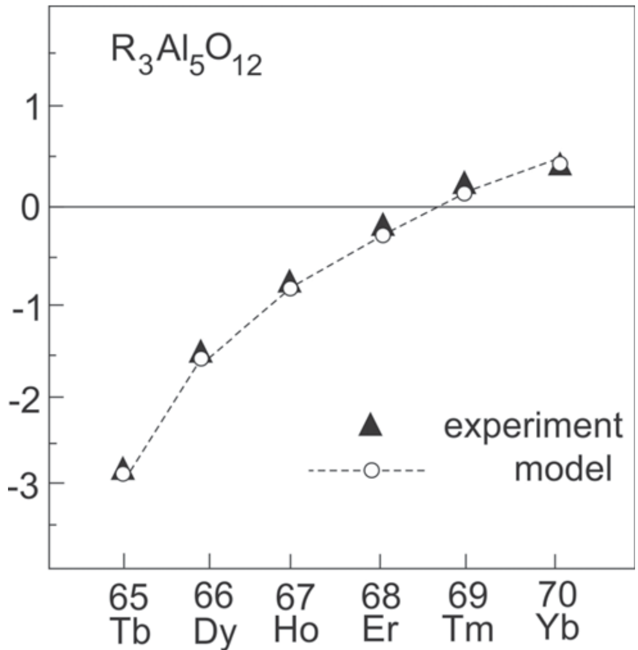

Fig. 3. Constant of Verde of rare-earth-aluminium garnets of $R_3Al_5O_{12}$, as function of atomic number of rare-earth element; model values are got in the this work, experimental - from data [4].

Conclusions

Research showed that a Faraday rotation is in the rare-earth grenades of $R_3Al_5O_{12}$ (R=Tb, Dy, Ho, Er, Tm, Yb) [4] it contingently, as well as electric polarizability of RIG [3], by the local magnetic fields created by the 4*f*- shells of rare-earth elements (type interaction «spin-another's an orbit») and operating, essentially, within the limits of atomic radius of rare-earth elements. Comparison of experimental data [4] with the model values (2-4) got in the real work allows to draw conclusion, that the use of model of local optical dipoles can profit at the study of magnetooptics properties of rare-earth garnets.

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