optica

Faraday rotation in iron garnet films beyond elemental substitutions: supplementary material

Miguel Levy[1,*], Olga V. Borovkova[2], Colin Sheidler[1], Brandon Blasiola[1], Dolendra Karki[1], François Jomard[3], Mikhail A. Kozhaev[2,4], Elena Popova[3], Niels Keller[3], Vladimir I. Belotelov[2,5]

[1]*Physics Department, Michigan Technological University, Houghton, Michigan 49931, USA*
[2]*Russian Quantum Center, Skolkovo, Moscow Region 143025, Russia*
[3]*Groupe d'Etude de la Matière Condensée (GEMaC), CNRS-UVSQ, Université Paris-Saclay, 78035 Versailles, France*
[4]*Prokhorov General Physics Institute RAS, Moscow 119991, Russia*
[5]*Lomonosov Moscow State University, Moscow 119991, Russia*
**Corresponding author: mlevy@mtu.edu*

Published 10 May 2019

DERIVATION OF THE FARADAY ROTATION EXPRESSION

The transmission coefficients for right- and left-circularly polarized light are given by

$$t^{\sigma}=\left(\frac{E_3^{\sigma}}{E_i^{\sigma}}\right)=\frac{2}{(1+n_3)\cosh\left(ik_0\tilde{n}_2h\right)-\left(\frac{n_3}{\tilde{n}_2}+\tilde{n}_2\right)\sinh\left(ik_0\tilde{n}_2h\right)}$$

(M1)

where $\sigma=\pm1$ denotes the optical polarization, E_i^{σ}, E_3^{σ} are the amplitudes of the incident and transmitted to the substrate light circularly polarized components, respectively, n_3 is the refractive index of the substrate, and where the refractive index of the ferrimagnetic film can be written as $\tilde{n}_2=\sqrt{n_2^2\pm g}$, $k_0=\frac{2\pi}{\lambda}$ is the wave number in vacuum, and λ is the wavelength [1].

From Eq. (M1) and the fact that $\sinh(ix)=i\sin x$ and $\cosh(ix)=\cos x$, one can find an expression (M2) for the transmitted light in terms of the component of the incident light

$$E_3^{\sigma}=\frac{2E_i^{\sigma}}{(1+n_3)\cos\left(\frac{2\pi}{\lambda}h\sqrt{n_2^2\pm g}\right)-i\left(\frac{n_3}{\sqrt{n_2^2\pm g}}+\sqrt{n_2^2\pm g}\right)\sin\left(\frac{2\pi}{\lambda}h\sqrt{n_2^2\pm g}\right)}$$

.(M2)

Consequently, the Faraday rotation (M3), taking into account surface reflections and absorption losses, can be expressed as

$$\theta=\frac{1}{2}\arg\left(\frac{E_3^{+}}{E_3^{-}}\right)=$$

$$=\frac{1}{2}\arg\left[\frac{(1+n_3)\cos\left(k_0\sqrt{\varepsilon_2-g}\,h\right)-i\left(\frac{n_3}{\sqrt{\varepsilon_2-g}}+\sqrt{\varepsilon_2-g}\right)\sin\left(k_0\sqrt{\varepsilon_2-g}\,h\right)}{(1+n_3)\cos\left(k_0\sqrt{\varepsilon_2+g}\,h\right)-i\left(\frac{n_3}{\sqrt{\varepsilon_2+g}}+\sqrt{\varepsilon_2+g}\right)\sin\left(k_0\sqrt{\varepsilon_2+g}\,h\right)}\right]$$

(M3),

where $\varepsilon_2=n_2^2$.

REFERENCE

1. A. Zvezdin and V. Kotov, Modern Magnetooptics and Magnetooptical Materials, *IOP* Bristol (1997).