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AN ELECTROMAGNETIC WAVE'S REFLECTION AND REFRACTION ON A TWO-LAYER MAGNETIC STRUCTURE

Maxmmudova Dilafruz Xasanovna
Tashkent Satate Transport University, Assistant

Abstract
In the study of nanostructures, the study of multilayer magnetic structures is of great importance. In this paper, we will consider a two-layer magnetic structure, the first layer of which is a film with a thickness ℓ magnetized in equatorial geometry, and the second layer is a substrate magnetized in polar geometry.

Keywords: reflection, refraction, waves, magnetic structure, electromagnets.

Introduction
The propagation of an electromagnetic wave in such a two-layer magnetic structure is, in general, a difficult problem. The dispersion equation is generally a sixth degree equation with respect to the components of the refraction vector. The equation includes a large number of material parameters, and it is extremely cumbersome. Even for a bigyrotropic medium, when the order of the dispersion equation is reduced to four, it continues to be quite complicated:

$$\varepsilon\mu n^4 + [\varepsilon(\mu_0-\mu)+\mu(\varepsilon_0-\varepsilon)]n^2(\vec{n}\vec{b})^2 + (\varepsilon_0-\varepsilon)(\mu_0-\mu)(\vec{n}\vec{b})^4 -$$
$$-[\mu_0\mu\varepsilon^2(1-Q^2)+\varepsilon_0\varepsilon\mu^2(1-M^2)]n^2 + [\mu_0\mu\varepsilon^2(1-Q^2)+\varepsilon_0\varepsilon\mu^2(1-M^2)-$$
$$-2\mu_0\mu\varepsilon_0\varepsilon(1+QM)](\vec{n}\vec{b})^2+\mu_0\mu^2\varepsilon_0+\varepsilon^2(1-Q^2)(1-M^2)=0$$

where:

$$\hat{\varepsilon} = \varepsilon + i\varepsilon Q b^{\times} + (\varepsilon_0-\varepsilon)\vec{b}\cdot\vec{b},$$
$$\hat{\mu} = \mu + i\mu M b^{\times} + (\mu_0-\mu)\vec{b}\cdot\vec{b},$$
$$\hat{\alpha} = \alpha + i\alpha L b^{\times} + (\alpha_0-\alpha)\vec{b}\cdot\vec{b},$$
$$\hat{\beta} = \beta + i\beta K b^{\times} + (\beta_0-\beta)\vec{b}\cdot\vec{b},$$

Here $\vec{b}$, is the unit vector of magnetization, $\hat{\varepsilon}$, $\hat{\mu}$, $\hat{\alpha}$, $\hat{\beta}$ are dielectric and magnetic permeability tensors, $\hat{\alpha}$, $\hat{\beta}$ are tensors associated with the excitation of a longitudinal wave. Q, M, L, K - magneto-optical parameters of the ferromagnetic medium. However, since the effects of magnetic gyrotropy and magnetic anisotropy in the optical frequency range are small, it may be limited to obtaining approximate solutions of the dispersion and wave equations.

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Methods

When a magnetic two-layer structure is magnetized (the first layer is in the equatorial geometry, and the second layer is in the polar geometry), when the incident electromagnetic wave is polarized in the plane of incidence, the relative change in the intensity of the reflected wave in the approximation linear in magnetization consists of two parts: δ_1 is the usual equatorial effect Kerr and δ_2 - the relative change in intensity resulting from the interference of waves reflected from the first and second interfaces [1]. As is known, when an electromagnetic wave is reflected from a massive homogeneous transparent sample, the intensity effect linear in magnetization, both in equatorial and polar geometries, is equal to zero [2]

Results

In the case of a two-layer magnetic structure, due to the presence of the second interface and the interference of waves reflected from both interfaces, a nonzero intensity magneto-optical effect arises when an electromagnetic wave is reflected from a transparent medium. For yttrium garnet in the transparency region: Faraday rotation α_{Φ} = 2x10^2 град/см, $\sqrt{\varepsilon = 2{,}2}$, $Q = 0.7x10^{-4}$, $\delta{\sim}10^{-4}$ [1].

Discussion

In the presence of a third interface, when the system contains two isotropic (vacuum) external media: medium 1, medium 4 and two internal media: medium 2, magnetized in equatorial geometry and medium 3, magnetized in polar geometry, the problem becomes more complicated. In magnetic media 2 and 3, three direct and three reverse electromagnetic waves are excited. Along with two transverse waves, one longitudinal wave is excited in each of the magnetic media. The solution of boundary problems on three interfaces allows calculating the reflection and refraction matrices.

Conclusion

The calculation of the equatorial Kerr effect shows that, in the approximation linear in magnetization, it depends on the magnetooptical parameters *Q*, *M*, *L*, and *K* and leads to the same effects as in [1].

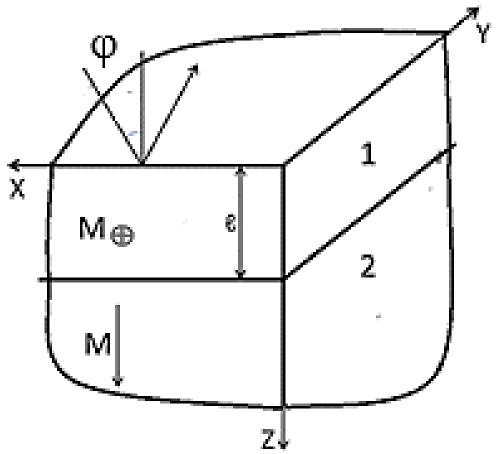

Fig 1. Schematic representation of the geometry of light reflection from a two-layer structure

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