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THE MAIN TYPES OF MAGNETO-OPTICAL EFFECTS

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ABSTRACT: This article describes a magneto-optical study of the faraday effect in rare-earth ferrite garnets. The Faraday effect is an odd magneto-optical effect in terms of magnetization, that is, the sign of the Faraday rotation depends on whether the direction of the light propagating in the crystal coincides with the direction of the magnetization vector M, or is antiparallel to the vector M. This circumstance underlies the well-known method of visual observation of magnetic domains in rare-earth ferrites - grenades.

KEYWORDS: Ferrite garnets, crystals, etipaxial films, plane-parallel plates.

INTRODUCTION

Magneto-optical phenomena include a group of phenomena associated with the properties of electromagnetic radiation in bodies placed in a magnetic field.

First of all, this is the Faraday effect; when linearly polarized light propagates in a substance along the magnetic field lines, a rotation of the plane of polarizations is observed. The angle of rotation is proportional to the length of the path of light in the substance and the strength of the magnetic field; it is natural that it also depends on the properties of the substance, the frequencies of light, optically active substances under the action of a magnetic field acquire an additional ability to rotate the plane of polarization, which is added to their natural ability. As usual, possible applications follow from the physical essence of the effect: control of the rotation of the plane of polarization using a magnetic field or measurement of magnetic fields by the angle of rotation.

THE MAIN FINDINGS AND RESULTS

A special case of the Faraday effect is the magneto-optical Kerr effect - when linearly polarized light is reflected at any angle, including along the surface normal, from a magnetized, ferromagnet, elliptically polarized light arises. In fact, the magneto-optical Kerr effect is the rotation of the polymerization plane in a thin surface layer of a ferromagnet.

There are also a number of magneto-optical phenomena. So, when light propagates in a substance perpendicular to the applied magnetic field, the phenomenon of double refraction also occurs with all the ensuing consequences (Cotton-Mouton effect). This effect is very small in magnitude; it was possible to reliably measure it in some liquids (benzene, acetone), glasses and colloids.

The mechanism of all magneto-optical phenomena is closely related to the mechanism of the direct and inverted Zeeman effect.

The direct (reverse) Zeeman effect consists in the splitting of the spectral lines of the emitted (absorbed) radiation if the emitting (absorbing) substance is in a magnetic field. The Zeeman effect is due to the splitting of the energy levels of atoms or molecules in a magnetic field; his complete theory is presented in any course of quantum mechanics. The Zeeman effect is studied in order to understand the laws of quantum systems such as atoms, the methods are spectral. The mechanism of the Faraday effect, in fact, is due to the inverted Zeeman effect.

The Faraday, Cotton-Mouton effects consist in the rotation of the plane of polarization and the appearance of ellipticity when linearly polarized light passes through a magnetized substance. In the case of the Faraday effect, the wave vector of the incident wave k is parallel to the magnetization vector M, in the case of the Cotton-Mouton effect, k is perpendicular to M. Similarly, depending on the relative position of the plane of incidence of the light wave, the direction of magnetization, and the normal to the surface of the sample, three types of the Kerr effect are distinguished:

- polar Kerr effect (PEC), the vector M is perpendicular to the boundary of the medium and parallel to the plane of incidence of light
- meridional Kerr effect (MEK), the vector M is parallel to the plane of incidence of light and the interface
- equatorial Kerr effect (EKE), vector M is parallel to the interface and perpendicular to the plane of incidence of light.

In the case of PEC, MEC (longitudinal phenomena) the effect lies in the rotation of the plane of polarization and the appearance of ellipticity when linearly polarized light is reflected from the surface of the sample. Longitudinal effects and the Faraday effect are due to the difference in the refractive indices in a magnetized medium of right and left circularly polarized light. The Cotton-Mouton effect arises due to the difference in the refractive indices of two linearly polarized components of light radiation, polarized parallel and perpendicular to the magnetization. EEC is observed only in absorbing materials and manifests itself in a change in the intensity and phase shift of linearly polarized light from the sample surface (compared to the case of M=0). All of the above effects are linear in magnetization.

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