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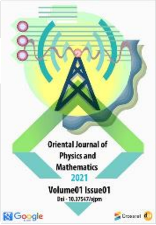

FARADAY EFFECT

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ABOUT ARTICLE

Key words: ferrite garnets, crystals, etipaxial films, plane-parallel plates

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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.

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MAQOLA HAQIDA

Kalit so‘zlar: ferrit granatalar, kristallar, etipaksiyal plyonkalar, tekis-parallel plitalar

Annotatsiya: Ushbu maqolada noyob yer ferrit granatalaridagi faraday effektining magnit-optik tadqiqi tasvirlangan. Faraday effekti magnitlanish nuqtai nazaridan g'alati magnit-optik effekt bo'lib, ya'ni Faraday aylanish belgisi kristalda tarqalayotgan yorug'lik yo'nalishi M magnitlanish vektori yo'nalishiga to'g'ri kelishiga yoki unga antiparallel bo'lishiga bog'liq. vektor M. Bu holat noyob yer ferritlari - granatalarda magnit domenlarini vizual kuzatishning taniqli usuli asosida yotadi.

ЭФФЕКТ ФАРАДЕЯ

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О СТАТЬЕ

Ключевые слова: ферриты-гранаты, кристаллы, этипаксиальные пленки, плоскопараллельные пластинки

Аннотация: В данной статье идёт описание магнитооптического исследования эффекта фарадея в редкоземельных ферритах-гранатах. Эффект Фарадея нечетный по намагниченности магнитооптический эффект, то есть знак фарадеевского вращения зависит от того, совпадает направление распространяющегося в кристалле света с направлением вектора намагниченности M, или антипараллельно вектору M. Это обстоятельство лежит в основе хорошо известного метода визуального наблюдения магнитных доменов в редкоземельных ферритах-гранатах.

KIRISH

In physics, the Faraday effect or Faraday rotation is a magneto-optical phenomenon, that is, the interaction between light and a magnetic field in a medium. (The effect is also sometimes called the magneto-optical Faraday effect or MOFE.) The Faraday effect causes a rotation of the plane of polarization, which is linearly proportional to the component of the magnetic field in the direction of propagation. Formally, this is a special case when the permittivity tensor is diagonal.

Discovered by Michael Faraday in 1845, the Faraday Effect method was the first experimental proof of the relationship between light and electromagnetism. The theoretical foundations of electromagnetic radiation (including visible light) were completed by James Clerk Maxwell in the 1860s and 1870s and Oliver Heaviside. This effect occurs in most optically transparent dielectric materials (including liquids) under the influence of magnetic fields.

THE MAIN RESULTS AND FINDINGS

The Faraday effect is caused by the propagation of waves with left and right circular polarization. at slightly different speeds, a property known as circular birefringence. Since linear polarization can be decomposed into a superposition of two circularly polarized components of equal amplitude, opposite directions and different phases, the effect of the relative phase shift caused by the Faraday effect is to change the orientation of the linear polarization of the wave.

The Faraday effect finds application in measuring instruments. For example, the Faraday effect has been used to measure the optical force of rotation and for remote sensing of magnetic fields (such as fiber optic current sensors). The Faraday effect is used in spintronics research to study the polarization of electron spins in semiconductors. Faraday rotators can be used for amplitude modulation of light and are the basis of optical isolators and optical circulators; such components are needed in optical telecommunications and other laser applications.

Linear polarized light rotating in the Faraday effect can be viewed as consisting of a superposition of a right-handed and a left-handed circularly polarized beam (this principle of superposition is fundamental in many areas of physics). We can look at the effects of each component (whether right or left polarized) individually and see what effect it has on the result.

In circularly polarized light, the direction of the electric field rotates with the frequency of the light either clockwise or counterclockwise. In a material, this electric field induces a force on the charged particles that make up the material (due to their small mass, the electrons are most affected). The movement thus produced will be circular, and the charges moving in the circle will create their own (magnetic) field in addition to the external magnetic field. So there will be two different cases: the field produced will be parallel to the external field for one (circular) polarization, and in the opposite direction for the other direction of polarization - thus the net field B increases in one direction and decreases in the opposite direction. This changes the interaction dynamics for each beam, and one of the beams will slow down more than the other, causing a phase difference between the left and right polarized beams. When the two beams are added after this phase shift, the result is again a linearly polarized beam, but rotated in the direction of polarization.

The direction of polarization rotation depends on the properties of the material through which the light passes. The full processing must take into account the effect of external and radiation-induced fields on the electron wave function, and then calculate the effect of this change on the refractive index of the material for each polarization to see if right or left circular polarization slows down more.

Radio waves passing through the Earth's ionosphere are also subject to the Faraday effect.

The ionosphere is made up of a plasma containing free electrons that contribute to the Faraday rotation according to the equation above, while positive ions are relatively massive and have little effect. Thus, in combination with the Earth's magnetic field, the polarization of radio waves rotates. Since the electron density in the ionosphere varies greatly on a daily basis, as well as during the sunspot cycle, the magnitude of the effect varies. However, the effect is always proportional to the square of the wavelength, so even at a UHF television frequency of 500 MHz ($\lambda = 60$ cm) more than a complete rotation of the polarization axis can occur. The consequence of this is that although most radio transmitting antennas are vertically or horizontally polarized, the polarization of a medium or short wave signal after reflection by the ionosphere is rather unpredictable. However, the Faraday effect due to free electrons decreases rapidly at higher frequencies (shorter wavelengths), so that at the microwave frequencies used by satellite communications, the transmitted polarization is maintained between the satellite and the ground.

In 2009, γ-Fe 2O3-Au core-shell nanostructures were synthesized to integrate magnetic (γ-Fe 2O3) and plasmonic (Au) properties into a single composite. Faraday rotation was tested with and without plasmonic materials, and an increase in rotation was observed when irradiated with 530 nm light. The researchers argue that the magnitude of the magneto-optical gain is determined primarily by the spectral overlap of the magneto-optical transition and plasmon resonance.

CONCLUSION

The presented composite magnetic/plasmonic nanostructure can be visualized as a magnetic particle embedded in a resonant optical cavity. Due to the high density of photonic states in the cavity, the interaction between the electromagnetic field of light and the electronic transitions of the magnetic material is enhanced, which leads to a greater difference between the rates of right and left circular polarization, thus enhancing the Faraday rotation.

In organic materials, the Faraday rotation is usually small, with the Verdet constant in the visible wavelength region on the order of a few hundred degrees per Tesla per meter decreasing proportionally to λ − 2 {\displaystyle \lambda ^{-2))\lambda ^{-2} in this areas. Although the Verdet constant of organic materials does increase due to electronic transitions in the molecule, the associated absorption of light makes most organic materials poor candidates for use. However, there are also isolated reports of large Faraday rotation in organic liquid crystals without associated absorption.

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