Photonics

Lecture 10-11

Acousto-optics
Faraday effect

By

Hiba Basim Abbas

Fourth stage

Department of medical physics

Al-Mustaqbal University-College

Acousto-optics

is a branch of physics that studies the interactions between sound waves and light waves, especially the diffraction of laser light by ultrasound (or sound in general) through an ultrasonic grating.

By varying the parameters of the acoustic wave, including the amplitude, phase, frequency and polarization, properties of the optical wave may be modulated. The acousto-optic interaction also makes it possible to modulate the optical beam by both temporal and spatial modulation.

A simple method of modulating the optical beam travelling through the acousto-optic device is done by switching the acoustic field on and off. When off the light beam is undiverted, the intensity of light directed at the Bragg diffraction angle is zero. When switched on and Bragg diffraction occurs, the intensity at the Bragg angle increases. So the acousto-optic device is modulating the output along the Bragg diffraction angle, switching it on and off. The device is operated as a modulator by keeping the acoustic wavelength (frequency) fixed and varying the drive power to vary the amount of light in the deflected beam.

There are several limitations associated with the design and performance of acousto-optic modulators. The acousto-optic medium must be designed carefully to provide maximum light intensity in a single diffracted beam. The time taken for the acoustic wave to travel across the diameter of the light beam gives a limitation on the switching speed, and hence limits the modulation bandwidth. The finite velocity of the acoustic wave means the light cannot be fully switched on or off until the acoustic wave has traveled across the light beam. So to increase the bandwidth the light must be focused to a small diameter at the location of the acousto-optic interaction. This minimum focused size of the beam represents the limit for the bandwidth

A **magneto-optic effect** is any one of a number of phenomena in which an electromagnetic wave propagates through a medium that has been altered by the presence of a quasistatic magnetic field. In such a medium, which is also called **gyrotropic** or **gyromagnetic**, left- and right-rotating elliptical polarizations can propagate at different speeds, leading to a number of important phenomena. When light is transmitted through a layer of magneto-optic material, the result is called the Faraday effect: the plane of polarization can be rotated, forming a Faraday rotator. The results of reflection from a magneto-optic material are known as the magneto-optic Kerr effect (not to be confused with the nonlinear Kerr effect).

In general, magneto-optic effects break time reversal symmetry locally (i.e. when only the propagation of light, and not the source of the magnetic field, is considered) as well as Lorentz reciprocity, which is a necessary condition to construct devices such as optical isolators (through which light passes in one direction but not the other).

Two gyrotropic materials with reversed rotation directions of the two principal polarizations, corresponding to complex-conjugate ε tensors for lossless media, are called optical isomers.

Acousto-optic tunable filter

The principle behind the operation of acousto-optic tunable filters is based on the wavelength of the diffracted light being dependent on the acoustic frequency. By tuning the frequency of the acoustic wave, the desired wavelength of the optical wave can be diffracted acousto-optically.

There are two types of the acousto-optic filters, the collinear and non-collinear filters. The type of filter depends on geometry of acousto-optic interaction.

The polarization of the incident light can be either ordinary or extraordinary. For the definition, we assume ordinary polarization.

Faraday effect

From Wikipedia, the free encyclopedia

Jump to navigationJump to searchThe **Faraday effect** or **Faraday rotation**, sometimes referred to as the **magneto-optic Faraday effect** (**MOFE**),[1] is a physical magneto-optical phenomenon. The Faraday effect causes a polarization rotation which is proportional to the projection of the magnetic field along the direction of the light propagation. Formally, it is a special case of gyroelectromagnetism obtained when the dielectric permittivity tensor is diagonal.[2] This effect occurs in most optically transparent dielectric materials (including liquids) under the influence of magnetic fields.

Discovered by Michael Faraday in 1845, the Faraday effect was the first experimental evidence that light and electromagnetism are related. The theoretical basis of electromagnetic radiation (which includes visible light) was completed by James Clerk Maxwell in the 1860s. Maxwell's equations were rewritten in their current form in the 1870s by Oliver Heaviside.

The Faraday effect is caused by left and right circularly polarized waves propagating at slightly different speeds, a property known as circular birefringence. Since a linear polarization can be decomposed into the superposition of two equal-amplitude circularly polarized components of opposite handedness and different phase, the effect of a relative phase shift, induced by the Faraday effect, is to rotate the orientation of a wave's linear polarization.

The Faraday effect has applications in measuring instruments. For instance, the Faraday effect has been used to measure optical rotatory power 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 required in optical telecommunications and other laser applications

The ionosphere

Radio waves passing through the Earth's ionosphere are likewise subject to the Faraday effect. The ionosphere consists of a plasma containing free electrons which contribute to Faraday rotation according to the above equation, whereas the positive ions are relatively massive and have little influence. In conjunction with the earth's magnetic field, rotation of the polarization of radio waves thus occurs. Since the density of electrons in the ionosphere varies greatly on a daily basis, as well as over the sunspot cycle, the magnitude of the effect varies. However the effect is always proportional to the square of the wavelength, so even at the UHF television frequency of 500 MHz (λ = 60 cm), there can be more than a complete rotation of the axis of polarization.

A consequence is that although most radio transmitting antennas are either 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 diminishes rapidly at higher frequencies (shorter wavelengths) so that at microwave frequencies, used by satellite communications, the transmitted polarization is maintained between the satellite and the ground.