Sixth lecture

Kerr modulator The optical frequency Kerr effect and Magneto optic devices

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Kerr Effect

Definition: a nonlinear interaction of light in a medium with an instantaneous response, related to the nonlinear electronic polarization.

The Kerr effect is a nonlinear optical effect which can occur when light propagates in crystals and glasses, but also in other media such as gases. It can be described as a change in refractive index caused by electric fields, and being proportional to the square of the electric field strength.

Kerr effect

by Dr. Rüdiger Paschotta

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Kerr Electro-optic Effect (DC Kerr Effect)

In this context, one considers a slowly varying electric field, which is applied to some medium, e.g. to a piece of glass using two electrodes. A light beam passing the glass can then experience a polarization-dependent change of optical phase which is proportional to the square of the voltage applied to the electrodes, i.e., to the square of the electric field strength. The polarization dependence implies that birefringence is induced even in an optical material which is naturally not birefringent. Subsequently, the considered piece of glass could be used as an electrically controllable waveplate.

Assuming a constant electric field strength over some path length *L*, the field-induced phase change is

$$\Delta\varphi = \frac{2\pi}{\lambda} L \Delta n = 2\pi K L E^2$$

where Δn is the difference in refractive index between two polarization directions (parallel and perpendicular to the electric field direction), *K* is the Kerr constant of the material and *E* is the applied electric field strength.

Optical Kerr Effect (AC Kerr Effect)

Another variant of the Kerr effect occurs without an externally applied electric field, based on the electric field of a **light** wave only. The Kerr effect is the effect of an instantaneously occurring **nonlinear** response, which can be described as modifying