Six lecture

The optical frequency Kerr effect

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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 the refractive index. In particular, the refractive index for the high intensity light beam itself is modified according to

$$\Delta n = n_2 \, I$$

- with the nonlinear index n2 and the optical intensity I, which is proportional to the modulus squared of the electric field strength. The n2 value of a medium is related to the third-order susceptibility χ(3) and can be measured e.g. with the z-scan technique. Note that in addition to the Kerr effect (a purely electronic nonlinearity), electrostriction can significantly contribute to the value of the nonlinear index [3, 4]. The electric field of light causes density variations (acoustic waves) which themselves influence the refractive index via the photoelastic effect. That mechanism, however, occurs on a much longer time scale and is thus relevant only for relatively slow power modulations, but not for ultrashort pulses.

- Fused silica, as used e.g. for silica fibers, has a nonlinear index of $\approx 3 \times 10^{-16}$ cm2/W. For soft glasses and particularly for semiconductors, it can be much higher, because it depends strongly on the band gap energy. The nonlinearity is also often negative for photon energies above roughly 70% of the bandgap energy (self-defocusing nonlinearity).
- The time- and frequency-dependent refractive index change leads to self-phase modulation and Kerr lensing, for different overlapping light beams also to cross-phase modulation. Note that the effective refractive index increase caused by some intense beam for other beams is twice as large as that according to the equation shown above, assuming that both beams are in the same polarization state.