5.5 Cascading Nonlinearities in Optical Four-Wave Mixing

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The origin of large nonlinear optical interactions and the development of materials with optimized properties for device applications are a hot topic of the present research in photonics. Optical phase conjugation and all optical switching have a great potential and will become even more appealing if suitable materials and the appropriate combination of effects are found. A search for good materials with large second- and third-order nonlinearities, with low linear and nonlinear absorption, with good mechanical and dielectrical stability and high optical damage threshold proceeds in several directions. On the material side, better inorganic or organic crystals, polymers, and semiconductors are produced and characterized, while new pheno-mena, like optical spatial solitons and cascading effects promise to improve device performance.

Our new results show that the third order nonlinear optical response may be enhanced through cascaded second order processes. In a crystal without inversion symmetry there exist two-step indirect contributions to third-order nonlinear optical processes (cascading). Contributions to optical four wave mixing occur through optical rectification and linear electro-optic effects. In contrast to cascading via second harmonic generation which has to satisfy strict phase matching condition, optical rectification is always allowed. In polar $KNbO_3$ and $BaTiO_3$ crystals we measured four-wave mixing in several geometries in order to evaluate the direct contribution of the third-order polarizabilities and the cascaded contribution. We have presented a theoretical model which agrees with the experiments and predicts that the cascading effect is large and that the contributing polarization gratings must be transversly polarized.