# Past and Present Aspects of The Self-Phase-Modulation of Optical Beams

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## SUMMARY

Optical self-action effects occur when an electromagnetic field induces a refractive change in the medium through which the field propagates. The change in index of refraction then exhibits a back-action on the field so as to influence its propagation characteristics. Both spatial and temporal effects occur as discussed in a recent overview paper by [1] The influence of these nonlinear effects can be significant.

In this effort we primarily consider the consequences of the phase evolution due to the temporal variation of this self-action, known as self-phase-modulation. While initially observed in association with self-trapped filaments of light in liquids, the development of low-loss optical fibers very rapidly led to its ease of generation and predictability. Recently the development of photonic crystal fibers [2] [3] has lead to a significant increase in the strength of self-action effects and numerous diverse applications have resulted.

We are in the process of reviewing the development of the discipline from the early years; in particular, its observation in self-trapped filaments and mode-locked laser pulses, to its more recent developments. There remain several outstanding problems to be addressed. In particular we are studying a generalization of the nonlinear schroedinger equation to including higher order linear and nonlinear diffraction terms and its influence on self-action effects.

The self-phase modulation of repetive pulses from mode-locked lasers, which results in an optical frequency comb, has been of recent interest. The interval and linewidth depend upon the stabilization of the pulse train. To lowest order, a slippage of the optical phase with respect to the pulse amplitude results in a perturbation of this frequency interval which can be measured experimentally. This is generally related to the first order dispersion coefficient. Higher order dispersion, which might be anticipated to give a frequency interval which varies linearly across the comb, does not appear to be influential. The role of self-phase modulation and other self-action effects in such pulse to pulse mutual coherence phenomena is of interest.

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[2] J. M. Dudley, G. Genty, and S. Coen, Reviews of Modern Physics **78**, 1135 (2006).
[3] F. Zolla, G. Renversez, A. Nicolet, B. Kuhlmey, S. Guenneau, and D. Felbacq, *Foundations of Photonic Crystal Fibers* (Imperial College Press, 2005), ISBN 1-86094-507-4.