Refraction at interfaces with X(5) nonlinearity: Snell's law & Goos-Hänchen shifts

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In this presentation, we give the first detailed overview of spatial soliton refraction at the planar interface between materials whose nonlinear polarization has contributions from both $\chi^{(3)}$ and $\chi^{(5)}$ susceptibilities [1]. The governing equation is of the inhomogeneous Helmholtz class with a cubic-quintic nonlinearity, and analysis is facilitated through the exact bright soliton solutions of the corresponding homogeneous problem [2]. By respecting field continuity conditions at the interface, a universal Snell's law may be derived for describing the refractive properties of soliton beams. This compact equation contains a supplementary multiplicative factor that captures system nonlinearity, discontinuities in material properties, and finite beam waists. Extensive numerical calculations have tested analytical predictions and provided strong supporting evidence for the validity of our modelling approach across wide regions of a six-dimensional parameter space. Theoretical predictions for critical angles are generally in good agreement with simulations of beams at linear and weakly-nonlinear interfaces, and we have quantified Goos-Hänchen shifts [3,4] in such systems (see Fig. 1).

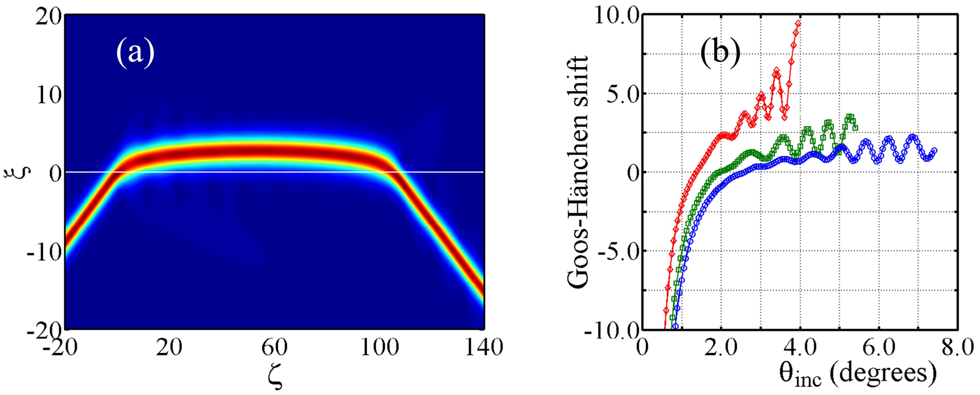

Figure 1. (a) A typical giant Goos-Hänchen (GH) shift at a cubic-quintic interface with external linear refraction [where the linear refractive index is higher in the second medium (region $\xi > 0$)]. (b) GH shifts at nonlinear interfaces can exhibit non-monotonic behaviour. In these simulations, the $\chi^{(3)}$ susceptibility is lower the second medium (while $\chi^{(5)}$ is uniform throughout) and the incident solitons have relatively high peak intensities to enhance self-focusing

References

[1] K. I. Pushkarov, D. I. Pushkarov, and I. V. Tomov, Opt. Quantum Electron. **11**, 471 (1979).
[2] J. M. Christian, G. S. McDonald, and P. Chamorro-Posada, Phys. Rev. A 76, 033833 (2007).
[3] F. Goos and H. Hänchen, Ann. Phys. **1**, 333 (1947).
[4] J. Sánchez-Curto, P. Chamorro-Posada, and G. S. McDonald, Opt. Lett. **36**, 3605 (2011).