Giant Goos-Hänchen shifts and soliton refraction in systems with $\chi^{(5)}$ susceptibility

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A full understanding of how a spatial solitons (a unique type of nonlinear light beam) behave when the encounter the boundary between two dissimilar media is still some way off. On the one hand, light-interface interactions underpin essentially all optical technologies. On the other hand, the overwhelming majority of the literature is rooted in paraxial theory [c.f. Aceves *et al.*, Phys. Rev. A vol. 39, 1809 (1989)], whereby angles of incidence, reflection, and refraction are vanishingly small (in the *laboratory frame*).

We will present our latest research into a new class of nonparaxial model describing arbitrary-angle refraction. Novelty arises by supplementing the traditional cubic response – or "$\chi^{(3)}$ susceptibility" – with an additional quintic contribution called the "$\chi^{(5)}$ susceptibility" [Pushkarov *et al.*, Opt. Quantum Electron. vol. 11, 471 (1979)]. This term plays an important role, and can dominate the system, when the incident laser light is sufficiently strong. Non-trivial generalizations of results from earlier collaborations, which accommodated susceptibilities only of the cubic type [Sánchez-Curto *et al.*, Opt. Lett. vol. 35, 1347 (2010); vol. 32, 1127 (2007)], will be discussed. Extensive theoretical predictions (from a newly-derived Snell's law) for beam refraction / critical angles in cubic-quintic material systems have generally been in good agreement with fully-numerical computations.

We have also made, to the best of our knowledge, the first predictions of giant Goos-Hänchen shifts [Goos and Hänchen, Ann. Phys. vol. 1, 333 (1947)] at cubic-quintic interfaces. A range of new qualitative phenomena, directly attributable to the effect of $\chi^{(5)}$ susceptibility, will be reported.