Abstract Submitted
for the MAR10 Meeting of
The American Physical Society

Soliton self-frequency shift in non-uniform fiber tapers: analytical description through an improved moment method ZHIGANG CHEN, ANTOINETTE TAYLOR, ANATOLY EFIMOV, Center for Integrated Nanotechnologies, Los Alamos National Laboratory, Los Alamos, NM 87545 — We develop an improved moment method derived from the generalized nonlinear Schrödinger equation to model soliton propagation in optical fibers. We account for the full Raman gain spectrum of the material and derive a system of coupled differential equations describing the evolution of the five moments of the optical pulse, valid for arbitrary soliton durations. We further simplify the equations by casting them into a moving frequency frame that follows the central frequency of the Raman-shifting soliton. We show that for short solitons there exists a non-negligible Raman-induced chirp, which contributes to slowing down the soliton self-frequency shift. By comparing with the numerical solution of the generalized nonlinear Schrödinger equation, the improved moment method is shown to accurately represent soliton self-frequency shift under higher order dispersion, self-steepening and pulse chirp. Numerical examples are presented for a dispersion-shifted fused silica fiber and a ZBLAN non-uniform fiber taper. The latter demonstrates enhanced soliton self-frequency shift through axial dispersion and nonlinearity engineering along the taper length.

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Date submitted: 18 Dec 2009 Electronic form version 1.4