Soliton Mediated Optical Quantization in Bragg Gratings

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An intense pulse of light launched into the anomalous dispersion regime of a fibre typically undergoes a nonlinear evolution in which it splits into a discrete number of soliton pulses and a background of dispersive waves, which eventually radiate away from the solitons. The solitons themselves do not undergo dispersive broadening as they are stabilized by the nonlinearity [1].

We find experimentally and numerically that the interaction of the inherent discreetness of soliton propagation phenomena with the band structure of gratings manifests in the quantization of the transmission, which takes the form of a well-defined staircase (Fig. 1, 3). Each of the steps of the staircase is related to the transmission of a new soliton (Fig. 2, 4). For a given detuning, in the band gap, the transmission increases dramatically if the input power is large enough to create a new soliton.

Fibre-Bragg-Gratings (FBGs) written in the core of photosensitive fibres by means of exposure to an UV hologram are an excellent system to experimentally study this discretization behaviour of pulses close to and inside the band gap of those FBGs. As shown below, experimental data is in good agreement with numerical calculations based on nonlinear coupled mode equations.

This effect of Soliton Mediated Optical Quantization (SMOQ) has, to the best of our knowledge, not yet been discussed or observed in any systems and is unique to periodic structures and represents a new insight into the fundamental properties of nonlinear excitations of periodic media.

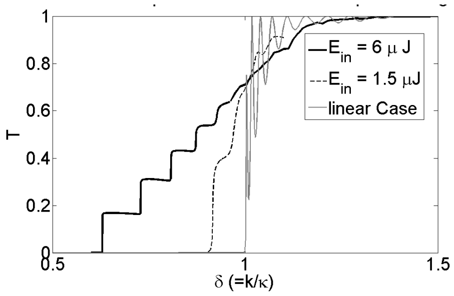

Fig 1. Simulated development of transmission staircase. L=100 mm, apodized, κ=500m^{-1}, FWHM=700ps. (solid gray) Linear, cw. (dotted black) E=1.5 μJ. (solid black) E=6 μJ.

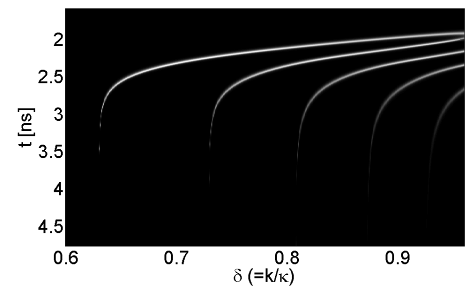

Fig 2. Simulated Time-resolved transmission spectrum. Each vertical slice depicts the temporal distribution of the optical power at the end of the FBG for a given detuning. Parameters as in Fig 1, solid black line

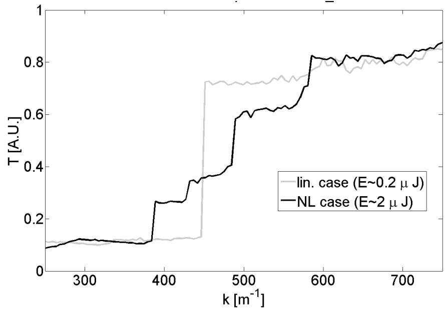

Fig 3. Experimental development of transmission staircase. L=90mm, apodized, κ=450m^{-1}, FWHM=700ps. (gray) E~0.2 μJ. (black) E~2μJ,

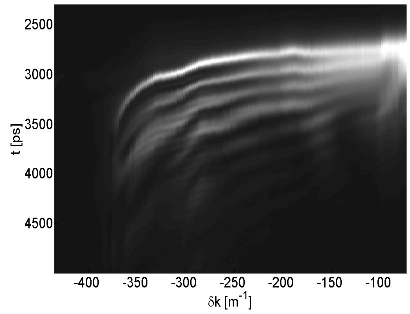

Fig 4. Time-resolved transmission spectrum. Each vertical slice depicts the temporal distribution of the optical power at the end of the FBG for a given detuning. Parameters as in Fig 3, black line.

References

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