Superfluid Optomechanical Dissipative Solitons

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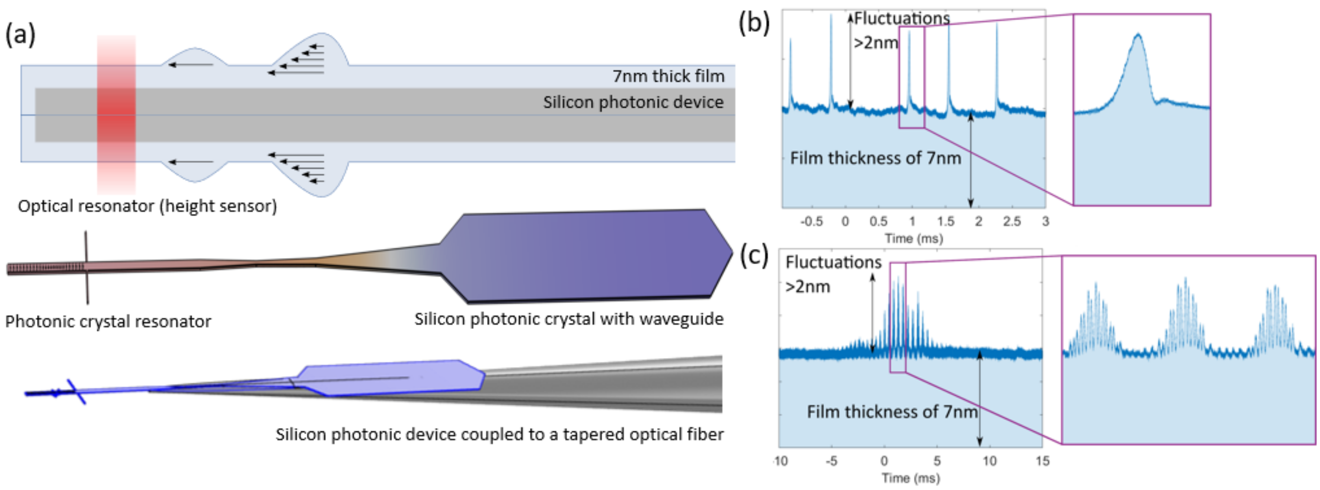

Figure 1: Summary of the superfluid optomechanical dissipative soliton experiment. (a) Diagrams of the 1D wavetank consisting of a 1D photonic crystal cavity at the end of a silicon waveguide. The optical cavity allows high precision measurements of the height at the location of the cavity. (b) Superfluid optomechanical dissipative solitons and other potentially interesting nonlinear behaviours.

Solitons are a localized wave-type solution common to a variety of complex nonlinear systems. They typically occur in systems when a nonlinear effect counteracts the natural frequency dispersion—famous examples include shallow water solitons, and more recently optical Kerr solitons which can be used to generate frequency combs. In such systems, they provide a useful simplified solution to the system, and can reveal information about the nonlinear system [1]. Since the 1980s solitons have been predicted to appear in thin-film superfluid ^{4}He, but have yet to be experimentally observed [2]. More recent studies use superfluid optomechanics, where the mechanical motion of the superfluid is coupled to an optical cavity. Leveraging our experiment in thin-film superfluid ^{4}He optomechanics [3, 4], we have made a miniscule 1D wavetank (5 fL of superfluid) with an optomechanical height sensor as shown in Figure 1 (a) allowing high precision read-out of the superfluid height at the cavity location. Experimental results of high amplitude waves and nonlinear phenomena including cnoidal waves, pulse trains and superfluid optomechanical dissipative solitons are presented, agreeing with the recently observed optomechanical dissipative solitons in solid state [5].

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