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Many-body quantum phenomena in fluids of nonlinear light

Abstract.--- In the presence of a significant optical nonlinearity, a beam of light may behave as a quantum fluid of interacting photons: One speaks of "quantum fluid of light." The ease of access to observables in these photonic systems make them especially promising for quantum simulation. An optical platform that presently attracts a growing interest within the community of quantum fluids of light consists in a paraxial beam of quasimonochromatic light propagating in a nonlinear optical medium. To begin with, I will review a general many-body quantum theory of light propagation in such a configuration. As a first application of this formalism, we will then see that a frictionless flow of superfluid light may be revealed from the dramatic cancellation of the optomechanical deformation of an elastic solid immersed into a nonlinear liquid or vapor. In a third part, I will present an in-progress pump-and-probe experiment of integrated silicon photonics aiming to extract the Bogoliubov dispersion relation of a fluid of light from the measurement of the probe's dephasing in a nonlinear channel waveguide. Fourthly, I will show that the propagating geometry constitutes a simple platform to investigate the dynamics of many-body quantum systems projected away from equilibrium after an interaction quench, including phenomena like the light-cone effect and prethermalization. A recent extension accounting for the presence of some disorder potential generated through cross-phase modulation in a nonlinear optical fiber will be sketched out. Before concluding, a mechanism of thermalization and evaporative cooling allowing a Bose-Einstein condensation of a quantum fluid of light will be presented.