Nonequilibrium precondensation of classical waves in two dimensions propagating through atomic vapors

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The nonlinear Schrödinger equation, used to describe the dynamics of quantum fluids, is known to be valid not only for massive particles but also for the propagation of light in a nonlinear medium, predicting condensation of classical waves. We report [1] on the initial evolution of random waves with Gaussian statistics using atomic vapors as an efficient two dimensional nonlinear medium. Experimental and theoretical analysis of near field images reveal a phenomenon of nonequilibrium precondensation, characterized by a fast relaxation towards a precondensate fraction of up to 75%. Examples of near field images are shown in Fig. 1 (a)-(c) for increasing interaction lengths with the corresponding intensity histograms shown in Fig. 1 (d)-(f) from which we extract the precondensation fraction. Such precondensation is in contrast to complete thermalization to the Rayleigh-Jeans equilibrium distribution, requiring prohibitive long interaction lengths.

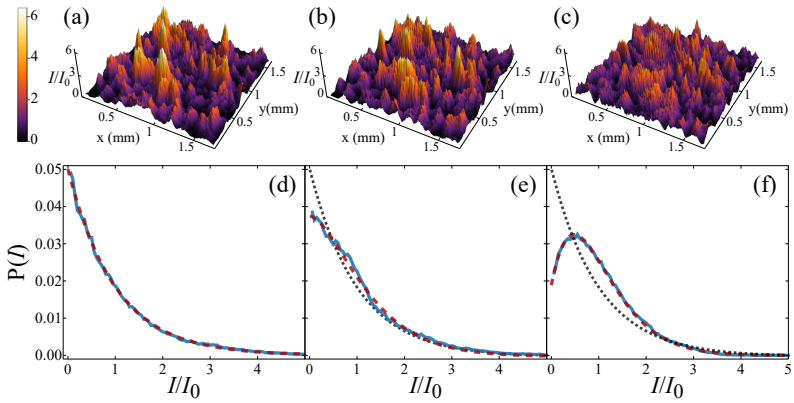

Figure 1. Near Field Speckle: (a)-(c) near field images for a nonlinear phase shift $\Phi_{NL} = 0$, 3.5π and 14.4π; (d)-(f): corresponding intensity histograms, showing the emergence of a nonzero value for the maximum of $P(I)$ with corresponding precondensation fractions n_0: (d) $n_0 = 0$, (e) $n_0/I_0 = 0.5$, (f) $n_0/I_0 = 0.7$. The dotted black line refers to the exponential (Gaussian statistics), the dashed red line is a fit to the predicted probability density.

[1] N. Šantić, A. Fusaro, S. Salem, J. Garnier, A. Picozzi, and R. Kaiser, Nonequilibrium Precondensation of Classical Waves in Two Dimensions Propagating through Atomic Vapors, Phys. Rev. Lett. **120**, 055301 (2018).