Blast waves in a paraxial fluid of light

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We use hot Rb vapor as a non-linear Kerr medium to produce a repulsively interacting (self defocusing) beam inside the cell. Under the paraxial approximation, the electric field envelope's propagation is analogous to the temporal evolution of a superfluid, described by the 2D Gross-Pitaevskii equation in the mean-field approximation.

Superfluid compressibility is known to give rise to a sound-like dispersion to the low amplitude waves. If the perturbation is strong, the sound velocity varies locally following the density inside the perturbation, giving rise to shock waves, a special type of waves changing their shape during propagation towards a steepening profile. In analogy with classical hydrodynamics, a blast wind, characterized by a negative differential pressure, should be observed in 2 and 3 dimensional space after the passage of a the shock wave front. A direct physical consequence of the blast wind is, for example, the presence of glass pieces within the building after an explosion inside an edifice. We report [1] a direct observation of the blast wind in our analogue optical superfluid. Interestingly, the blast wind is present in the case of a 2D perturbation and absent in the 1D geometry. Simplicity of the experiment as well as the unprecedented control enables the measurement of the time evolution as well as the time snapshots (spatial map of a physical quantity at fixed time) typically not accessible in classical hydrodynamics experiments.

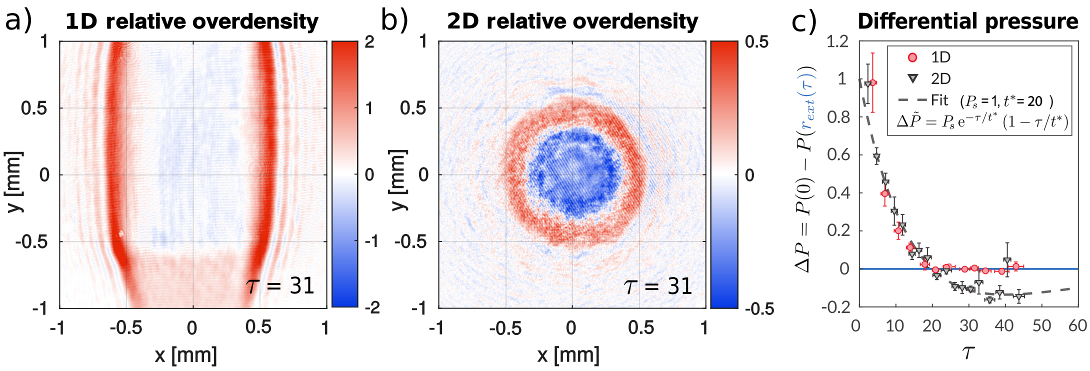

Figure 1. a), b) Relative overdensity at a given effective time in the 1D and 2D geometries, respectively. c) Time evolution of the differential pressure inside and outside the perturbation in the 1D and 2D configurations.

[1] Murad Abuzarli, Tom Bienaimé, Elisabeth Giacobino, Alberto Bramati and Quentin Glorieux, Blast waves in a paraxial fluid of light, arXiv, **2101.09040**, (2021).