Probing particle-particle correlation in harmonic traps with twisted light

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We explore the potential of twisted light as a tool to unveil many-body effects in parabolically confined systems. According to the Generalized Kohn Theorem, the dipole response of such a multi-particle system to a spatially homogeneous probe is indistinguishable from the response of a system of non-interacting particles. Twisted light however can excite internal degrees of freedom, resulting in the appearance of new peaks in the even multipole spectrum which are not present when the probe is a plane wave. We also demonstrate the ability of the proposed twisted light probe to capture the transition of interacting fermions into a strongly correlated regime in a one-dimensional harmonic trap. We report that by suitable choice of the probe's parameters, the transition into a strongly correlated phase manifests itself as an approach and ultimate superposition of peaks in the second order quadrupole response. These features, observed in exact calculations for two electrons, are reproduced in adiabatic Time Dependent Density Functional Theory simulations.