Spontaneous solitons in the thermal equilibrium of a quasi-1D Bose gas

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Abstract

We show that solitons occur generically in the thermal equilibrium state of a weakly-interacting elongated Bose gas, without the need for external forcing or perturbations. This reveals a major new quality to the experimentally widespread quasicondensate state, usually thought of as primarily phase-fluctuating. Thermal solitons are seen in uniform 1D, trapped 1D, and elongated 3D gases, appearing as shallow solitons at low quasicondensate temperatures, becoming widespread and deep as temperature rises. This behaviour can be understood via thermal occupation of the Type II excitations in the Lieb-Liniger model of a uniform 1D gas. Furthermore, we find that the quasicondensate phase includes very appreciable density fluctuations, while leaving phase fluctuations largely unaltered from the standard picture derived from a density-fluctuation-free treatment. Solitons in thermal equilibrium imply a kind of anti-Kibble-Zurek mechanism, where defects form when the temperature is raised.