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### Bose-Einstein Condensates in Ring Traps: Topological Unwinding, Strongly Correlated Solitons, and Metastable Quantum Phase Transitions

One-dimensional quantum gases on the 1D ring offer a highly tunable quantum many body system with the possibility of non-trivial topologies. and can be studied via a plethora of methods, from analytical to numerical to experimental. Taking our model as the rotating Lieb-Liniger Hamiltonian, we show theoretically that past a critical boundary in the interaction-rotation plane a finite-size metastable generalization of a quantum phase transitions occurs: the average angular momentum per particle abruptly changes from quantized, to continuously variable. Past this boundary a superfluid can be continuously wound and unwound. We identify the Yrast states as the key players in this quantum phase transition. We explain how macroscopic features like solitons emerge from the microscopic many body physics. We find the quantum generalization of dark solitons and superflow from the weakly interacting system all the way to the most strongly interacting, Tonks-Girardeau regime.

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