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Quantum phase transitions, symmetry breaking, and the Goldstone mode in metastable Bose-Einstein condensates[1] RINA KANAMOTO, Department of Physics, The University of Arizona, Tucson, AZ, USA, LINCOLN CARR, Department of Physics, Colorado School of Mines, Golden, CO, USA, MASAHITO UEDA, Department of Physics, Tokyo Institute of Technology, Tokyo, Japan — It is widely believed that the circulation in a repulsive superfluid system is quantized and that there is a discontinuous jump in states between different values of the circulation. We point out that this rule applies only to the ground state, and that continuous transitions between different values of the circulation do occur for metastable states of repulsive Bose-Einstein condensates on a ring. The key to these continuous transitions is the emergence of a dark or grey soliton train that carries a non-integer portion of the circulation. Mean-field theory shows that these continuous changes can be classified as second-order quantum phase transitions between metastable states, where quantized rotation and the soliton state are associated with bifurcations of metastable solutions. We also investigate this problem using quantum field theory, where the broken-symmetry solution and appearance of the Goldstone mode are described by a linear superposition of the quasidegenerate eigenstates of the many-body Hamiltonian.

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