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Virial theorems and vortex states in confined Bose-Einstein condensates[1] STAVROS KOMINEAS, NIGEL COOPER, University of Cambridge, NIKOS PAPANICOLAOU, University of Crete — We derive a class of virial theorems which provide stringent tests of both analytical and numerical calculations of vortex states in a confined Bose-Einstein condensate. In the special case of harmonic confinement we arrive at the surprising conclusion that the linear moments of the particle density, as well as the linear momentum, must vanish even in the presence of off-center vortices which lack axial or reflection symmetry. The effect of anharmonic confinement is also discussed. Two types of non-axisymmetric vortices have been observed to precess around the center of the condensate and they are refered to as the S-vortex and the U-vortex. We study numerically (Gross-Pitaevskii equation) and theoretically a single vortex in spherical and elongated condensates as a function of the interaction strength. For a given angular momentum the S-vortex has smaller precession frequency and a higher energy than the U-vortex in a rotating elongated condensate. We show that the S-vortex is related to the solitonic vortex and also to the dark soliton which are nonlinear excitations in the nonrotating system. In the dilute limit a lowest Landau level calculation provides an analytic description of these vortex modes. (Phys. Rev. A 72, 053609 (2005), Phys. Rev. A 72, 053624 (2005))

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