Critical Rotational Conditions for Breakup of Quadratic-Quartic Pancake-Like Confined Bose-Einstein Condensates

L Tomio[1], L Brito[2], A Andreati[2], and A Gammal[2]

[1] *Institute of Theoretical Physics, Universidade Estadual Paulista, 271 Rua Bento Teobaldo Ferraz, Barra Funda, 01140-070, São Paulo, Brazil. Contact Phone: +551133937809*
[2] *Institute of Physics, Universidade de São Paulo, 1371 Rua do Matão, 05508-090, São Paulo, Brazil*
Contact Email: lauro.tomio@gmail.com

An investigation performed in [1], supplemented by further details, is reported, by considering the solution of the two-dimensional Gross-Pitaevskii (GP) formalism, in which it was established the critical rotational conditions for the breakup of two kinds of quadratic-quartic pancake-like confined condensates. The first trap is quadratic in a single $x-$direction, with the second quadratic in the radial $r(x,y)-$direction. The threshold conditions to produce a giant vortex at the center of the vortex-pattern distributions were also verified. For such a study, both the Thomas-Fermi (TF) approximation and exact numerical approach were applied. Besides not being able to provide the full vortex pattern structure, the TF approximation was shown to be quite realistic in establishing the critical conditions, even for such a high rotating system, when it is fragmented in two confined clouds. These results have particular relevance in defining the rotation and trap parameters for any further related studies on the vortex pattern dynamics. By following the full-numerical GP solution, the applicability of the Feynman rule to the vortex distribution was also confirmed even for these non-homogeneous trap configurations. A sample numerical result for the first kind of trap is shown in the attached figure, extracted from [1], for the density distribution and corresponding vortex patterns, in which was taken a large repulsive nonlinear two-body interaction. The rotational frequencies are just before and after the breakup, respectively, $\Omega = 0.7$ and $\Omega = 0.77$ (units of the transversal frequency). The TF boundaries are shown by the dashed lines.

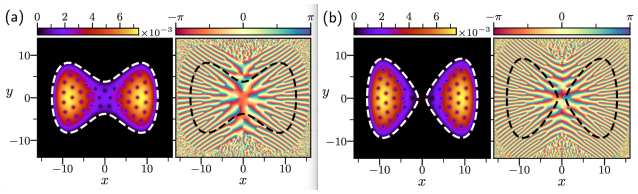

Figure 1: Density distributions with corresponding phase diagrams showing the vortex patterns for the rotational frequencies 0.7 (left) and 0.77 (right); before and after the breakup. The TF results are shown by the dashed lines

References

[1] L Brito, A Andriati, L Tomio and A Gammal, Phys. Rev. A **102**, 063330 (2020)