Quantized Vortices in Superfluids - a Mathematical and Computational Study

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The appearance of quantized vortices is a typical signature of superfluidity. It has received a lot of attention in the studies of superfluid Helium, superconductivity and more recently the Bose-Einstein condensation. The significance of the research on the quantized vortex phenomena is recently highlighted by the recent Nobel Physics Prizes in the years 2001 and 2003.

Throughout the last few decades, both theoretical and computational studies have shed light on the characteristics of the quantized vortex nucleation and dynamics. In this short lecture notes, we intend to provide a concise description of the physical background, several relevant mathematical models, and the numerical methods developed for the study of the motion and interaction of quantized vortices in various contexts. In particular, we emphasize on issues related to the celebrated Ginzburg-Landau models of superconductivity and the mean field Gross-Pitaevskii equations. Much of the discussions given here are taken from our earlier works in the field.