Working document on BEC :

internship at LJLL with I.Danaila and F.Hecht

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1 Post-processing of BEC simulations using FreeFem++

This work was performed in 2D : thus we are looking at a $3D$ surface defined by ${}^t\big(x, y, \rho(x, y)\big)$.

1.1 How to retrieve the vortex from a simulation

This analysis suggested here relies on a module available in *isoline.cpp* which is called *findalllocalmin*. It allows to find all basins of attraction for a certain surface: for each vortex, it gives the elements of the mesh that defines it.

An issue comes from the simulation in itself: as the algorithm extracts all local minima, some artefacts exist due some small disruptions of the surface. A way to get around the problem is to use the quantification of the vortices. Indeed solution to GPE contains vortices with a charge ± 1 (charge larger than or equal to 2 are thermodynamically unstable). Now the n-charge is defined as :

$$\Gamma = \oint \mathbf{v} dl = n\frac{h}{m}$$

$$\widetilde{\Gamma} = \oint \nabla S dl = 2\pi n$$

with $\psi(t, \mathbf{r}) = \sqrt{\rho(t, \mathbf{r})} e^{iS(t,\mathbf{r})}$ the wave function,

and $\mathbf{v} = \dfrac{\hbar}{m}\nabla S$ where m is the mass of the particules.

A way to analyse if a basin of attraction contains a vortex is to compute this integral and to store only the basin the integral of which equals to $\pm 2\pi$. In Freefem++, this is how it is written :

1: $\int_{1D}$