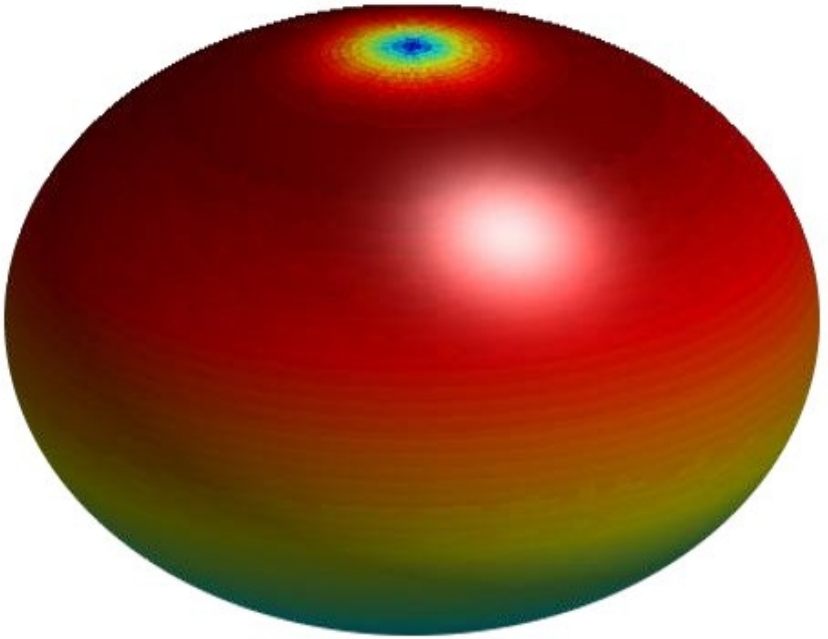
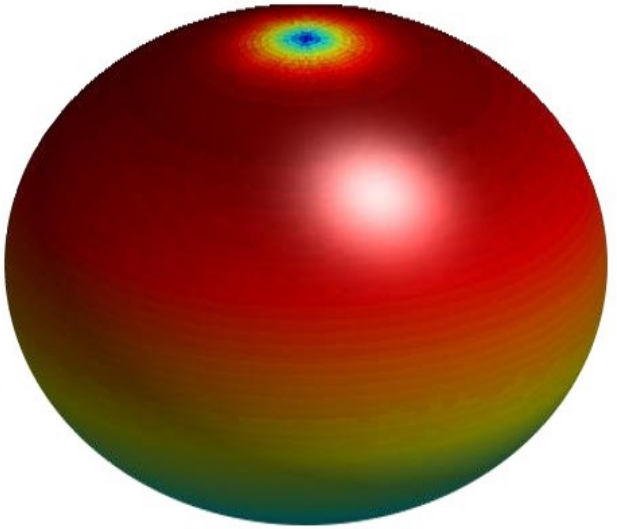
S K Y R M I O N S



Gergely Zaránd
Márton Kanász-Nagy
Balázs Dóra

Skyrmion?

- Topological Q-state
- Cold atoms in a trap
- 2 component Bose superfluid



Skyrmion?

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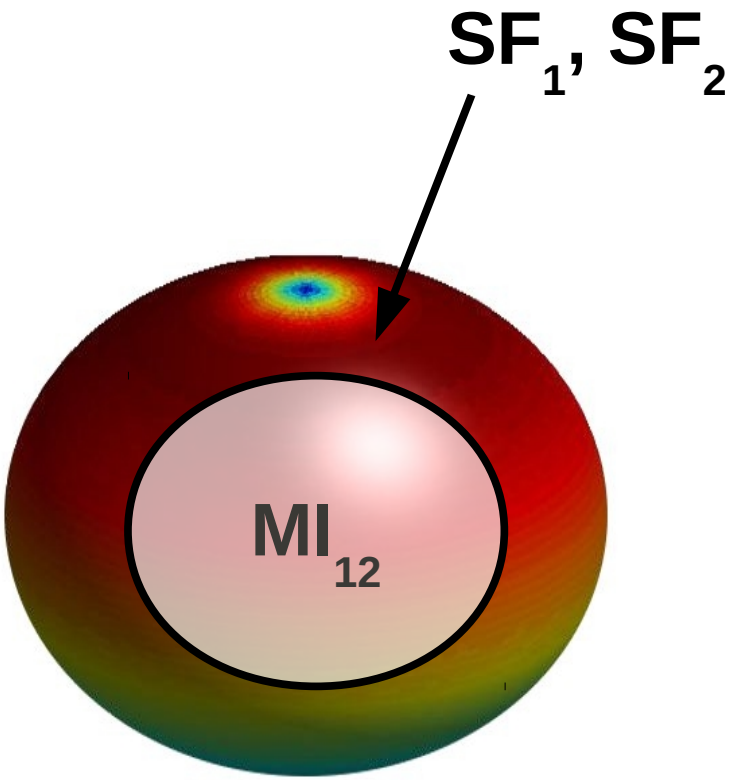


Skyrmion?

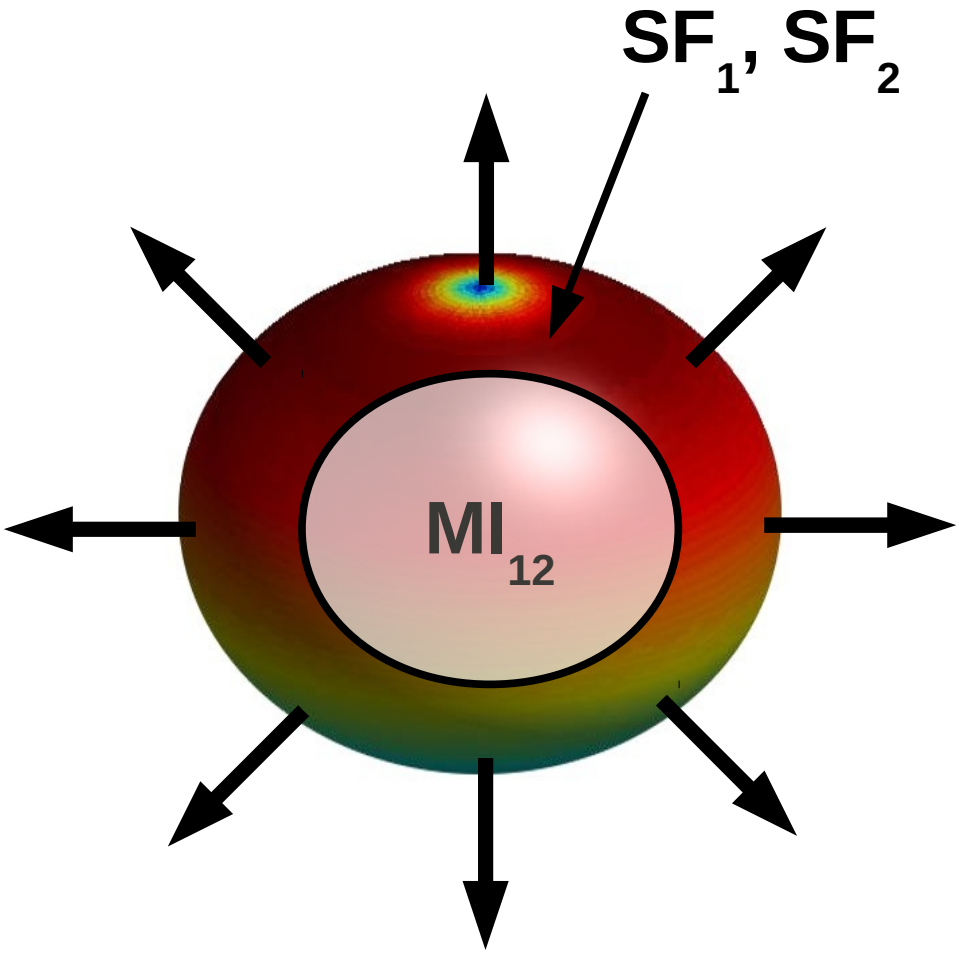
- Topological Q-state
- Cold atoms in a trap
- 2 component Bose superfluid

'Dirac-monopole on a sphere'

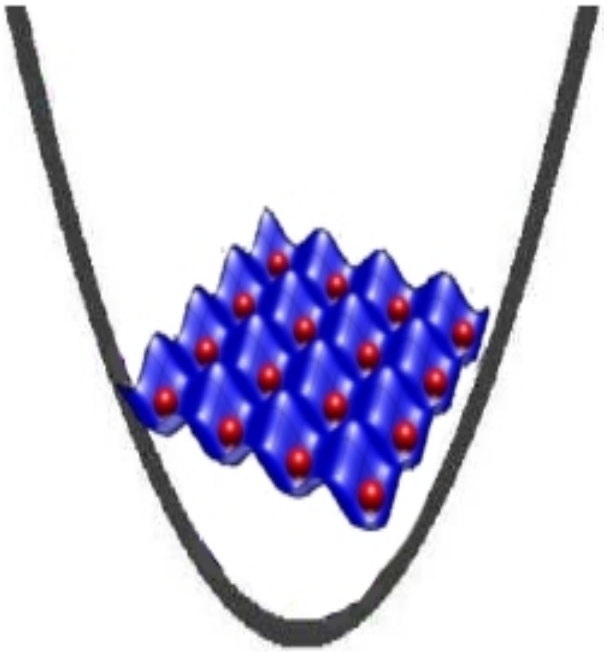
- SF order parameters
- $(\psi_1,\psi_2) \Leftrightarrow$ spin

Should be

- self-sustained
- long lifetime
- easy to manipulate



THE PHYSICAL SYSTEM



Two component bosons

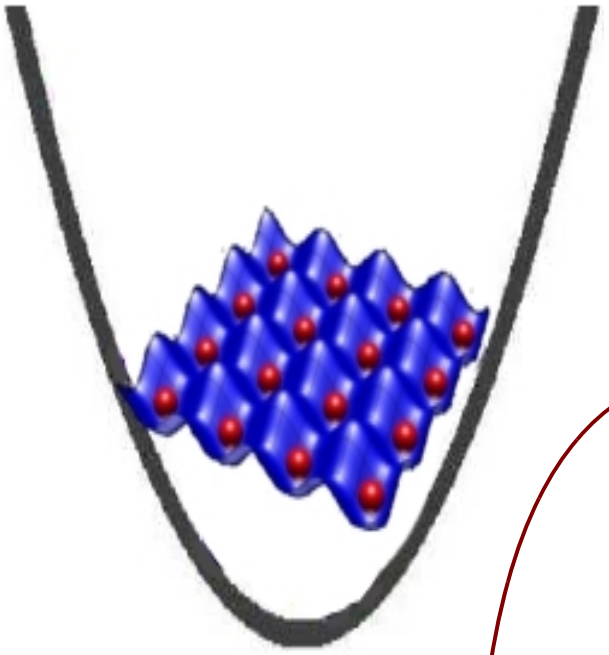
Repulsive interactions

Trapping potential

$$-\mu_\alpha(\mathbf{r}) = -\mu_\alpha^{(0)} + U_{\mathrm{trap}}(\mathbf{r})$$

Deep optical lattices

THE PHYSICAL SYSTEM



Two component bosons

Repulsive interactions

Trapping potential

$$-\mu_\alpha(\mathbf{r}) = -\mu_\alpha^{(0)} + U_{\rm trap}(\mathbf{r})$$

Deep optical lattices

⇩

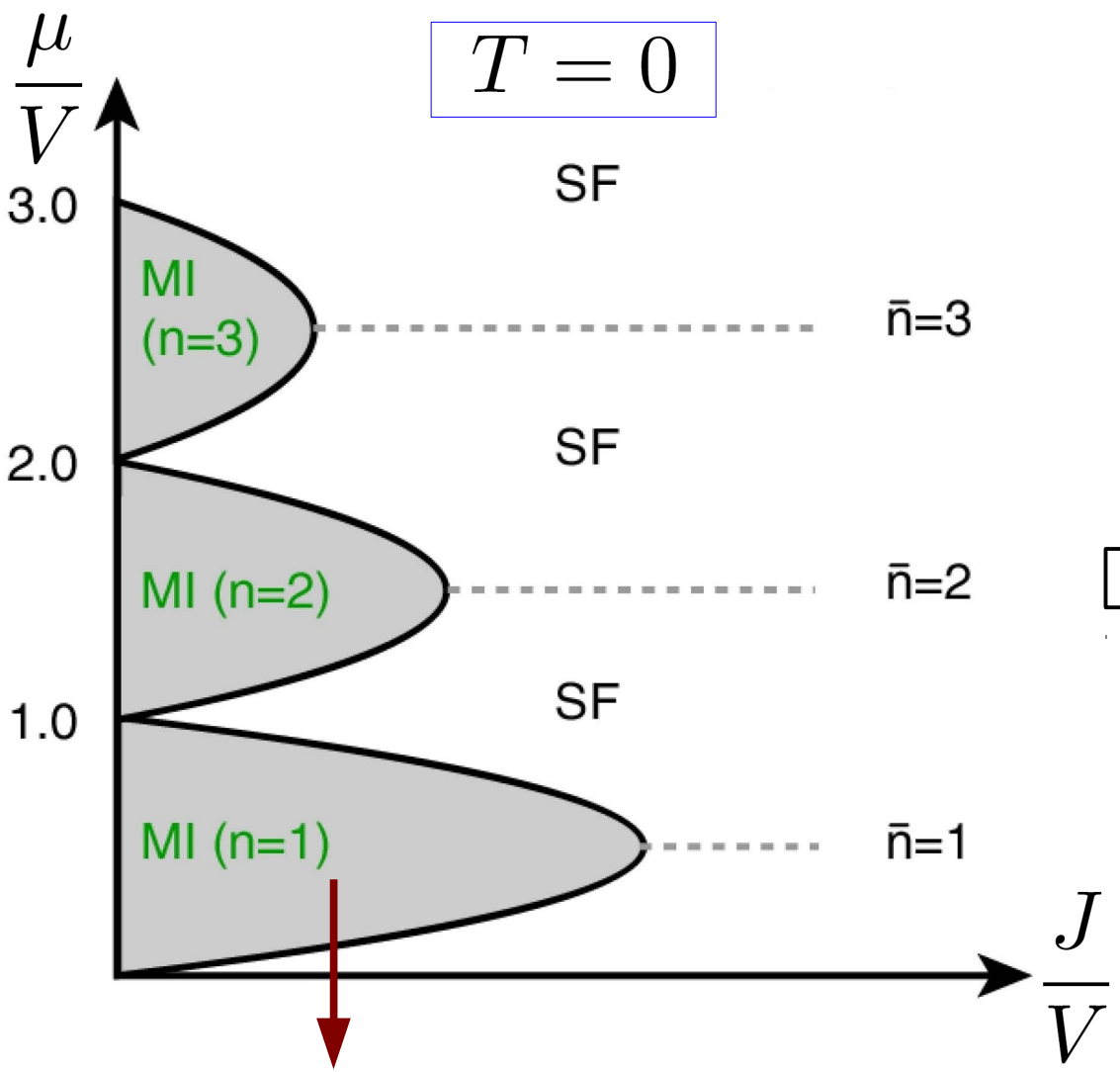
Two-component Bose-Hubbard model (one band)

$$H_0 = \sum_{\alpha i} -\mu_{\alpha i}\, a^\dagger_{\alpha i} a_{\alpha i} + \frac{1}{2}\sum_{\alpha\beta i} V_{\alpha\beta}\, a^\dagger_{\alpha i} a^\dagger_{\beta i} a_{\beta i} a_{\alpha i},$$

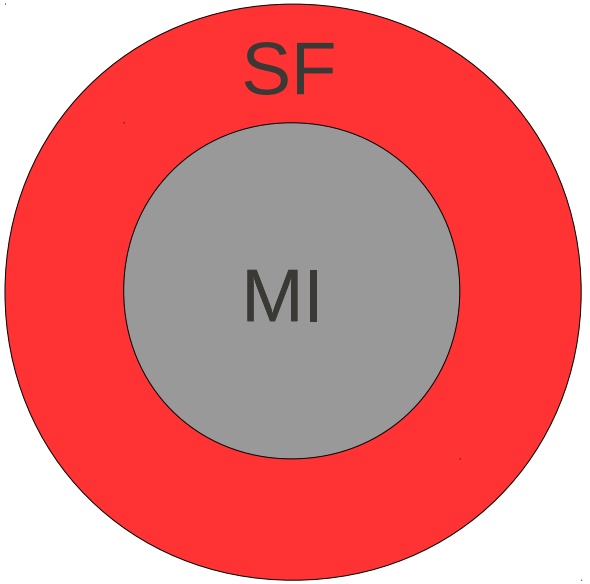
$$H_1 = -\sum_{\langle i,j\rangle\alpha} J_{ij\alpha}\, a^\dagger_{\alpha i} a^\dagger_{\alpha j}.$$

$$V_{11} = V_{22} < V_{12}$$

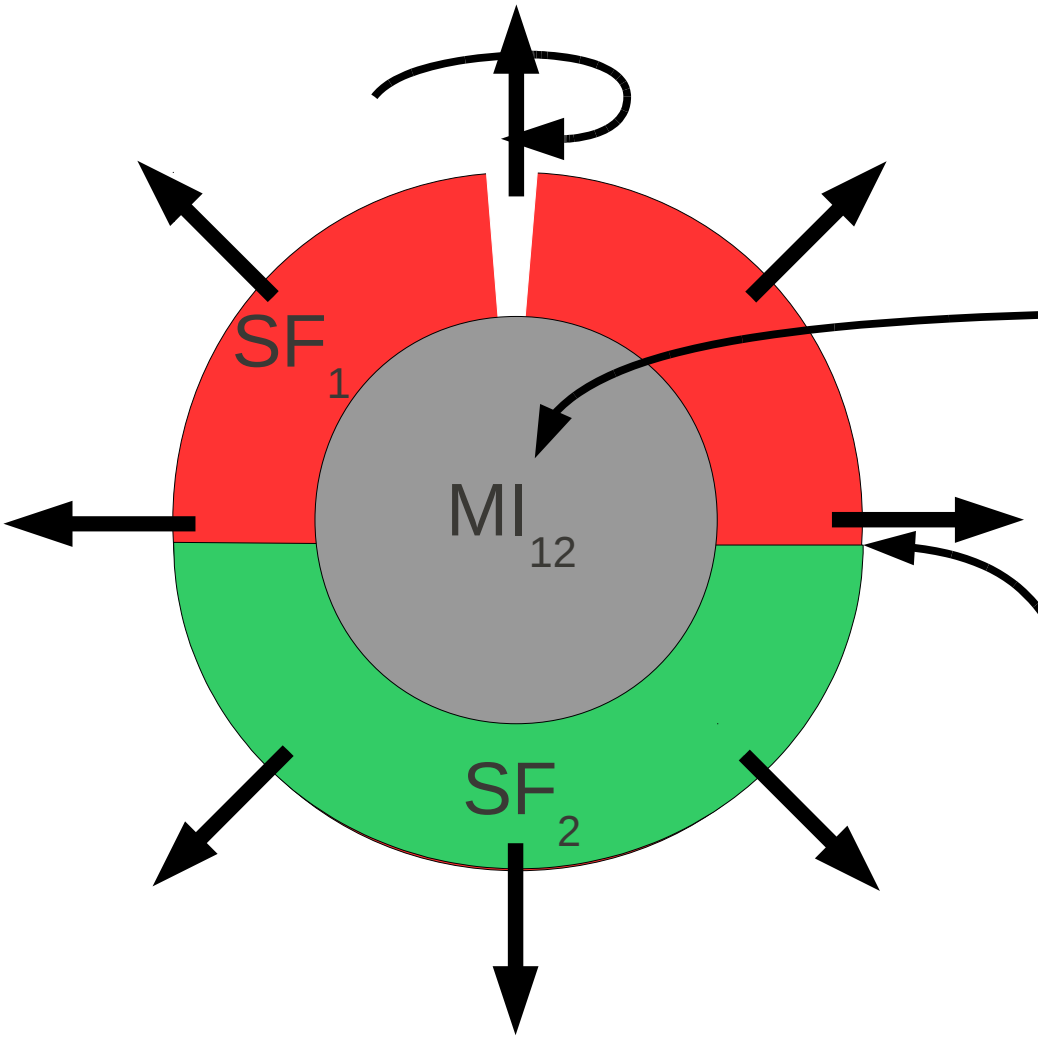
SF-MI TRANSITION FOR ONE COMPONENT



Shell structure



TWO COMPONENTS



$$\frac{J^2}{V_\alpha} \ll T \ll V_\alpha$$

⇩

Homogenous mixture
in the MI phase

$$V_{11} = V_{22} \lesssim V_{12}$$

⇩

Phase separation
in the SF phase

SF order parameters: (ψ_1,ψ_2) ⟺ spin ⇨ '2D Dirac monopole'

METHODS

$H = H_0 + H_1, \quad H_1$ is perturbation.

Hubbard-Stratonovich,
SF order parameters: (ψ_1,ψ_2)

$$S_{\text{eff}} = \int \mathrm{d}^3\mathbf{r}\,\mathrm{d}\tau \sum_\alpha \left(\frac{|\nabla\psi_\alpha|^2}{2} + M_\alpha|\psi_\alpha|^2 + \sum_\beta \frac{U_{\alpha\beta}}{2}|\psi_\alpha|^2|\psi_\beta|^2 \right)$$

Saddle point approximation

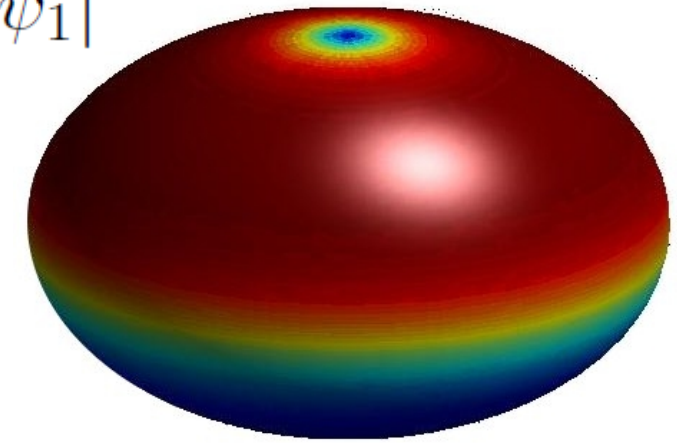
Minimization of S_{eff} $\Rightarrow$ ψ_α^{SP}

Method: imaginary time Gross-Pitaevskii equation:

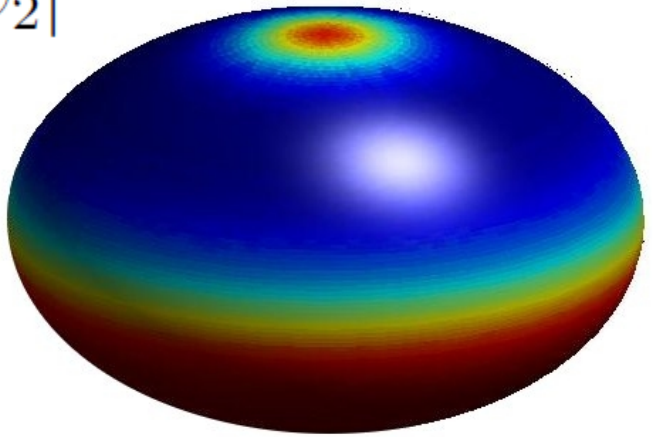
$$-\partial_\tau \psi_\alpha = \frac{\delta S_{\text{eff}}}{\delta \psi_\alpha}$$

PRELIMINARY RESULTS

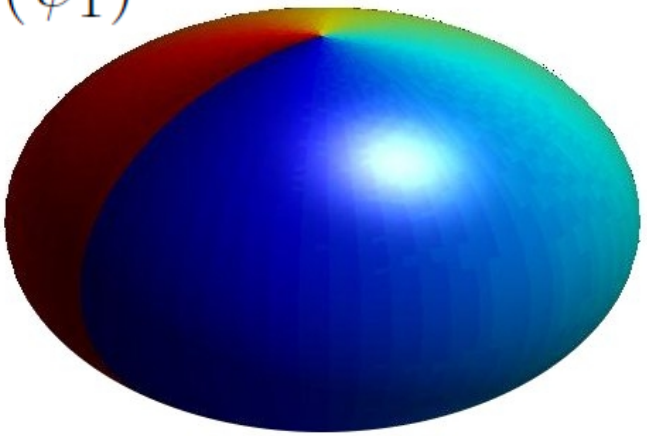
$|\psi_1|$



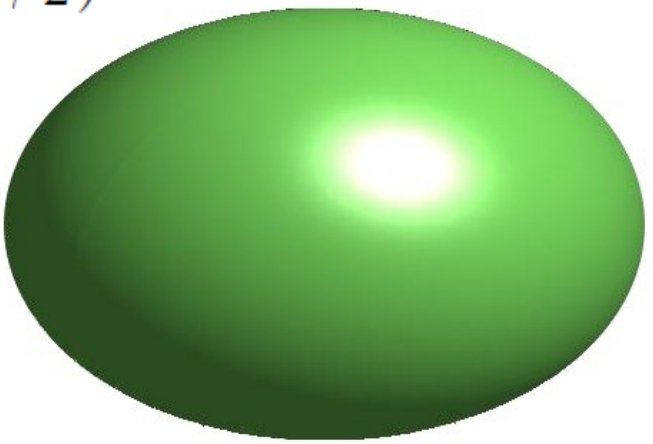
$|\psi_2|$



$arg(\psi_1)$



$arg(\psi_2)$



PRELIMINARY RESULTS

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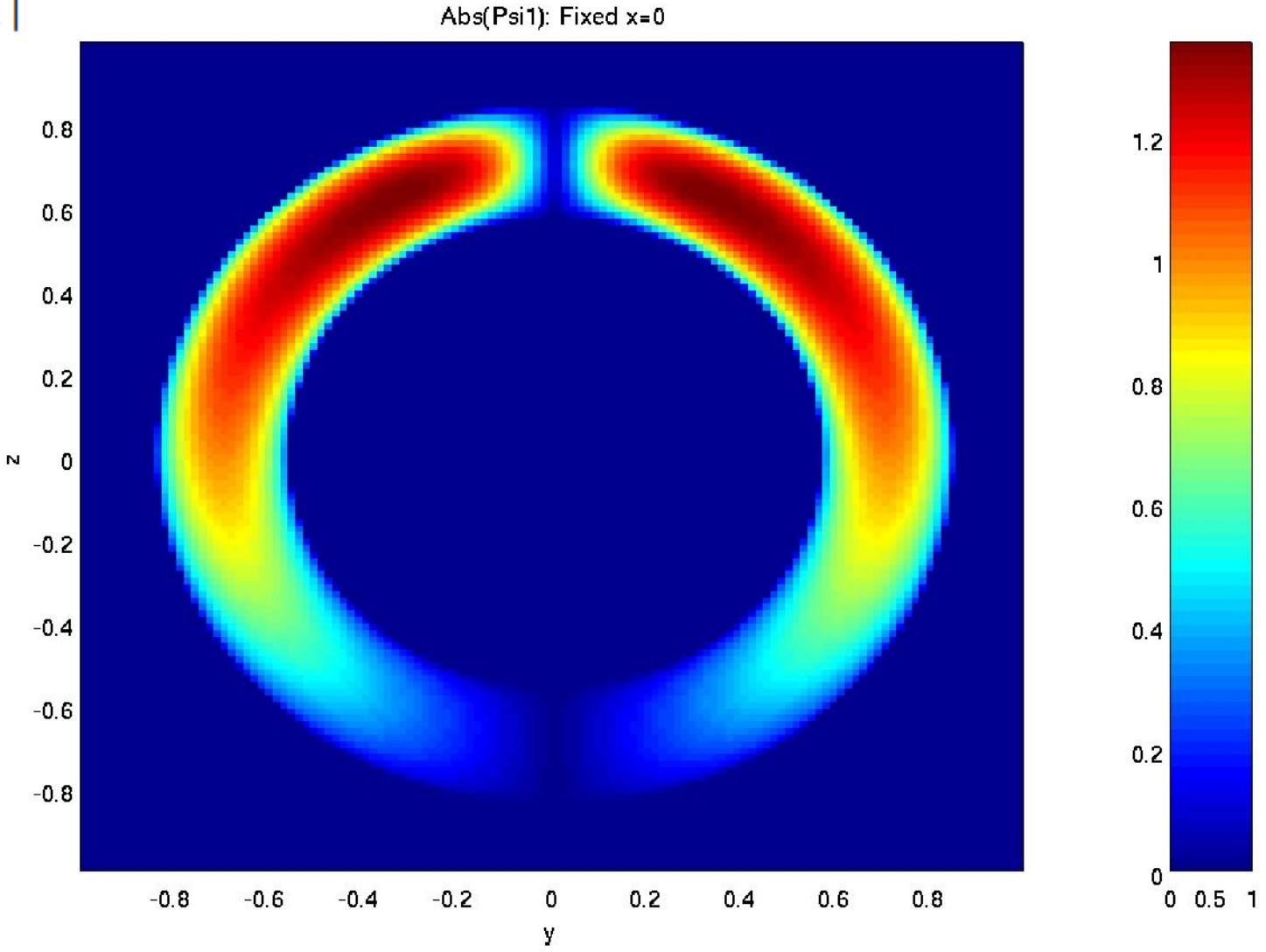

OPEN PROBLEMS

- Fix particle numbers *?*
- Role of the MI *?*
- Decay time *?*
- Decay processes *?*
- Creation of the skyrmion *?*