Stochastic quantum hydrodynamics for Bose-Einstein condensates

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Matter wave field: $\Psi(\mathbf{x}) = \sqrt{n(\mathbf{x})}\, e^{i\theta(\mathbf{x})}$ $\quad \mathbf{v}(\mathbf{x}) = \frac{\hbar}{m}\nabla\theta(\mathbf{x})$ $\quad$ interaction g

Continuity:

$$\frac{\partial n}{\partial t} = -\nabla\cdot[n\mathbf{v}] + \sqrt{-i\frac{g}{\hbar}}\,\xi(t)$$

Incompressible hydrodynamics $\quad$ Quantum pressure $\quad$ Quantum noise

Euler equation:

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v}\cdot\nabla)\,\mathbf{v} = -\nabla\left[V_{\mathrm{trap}}(\mathbf{x}) + gn - \frac{\hbar^2}{2m\sqrt{n}}\nabla^2\sqrt{n} - \frac{\sqrt{i\hbar g}}{2}\,\xi(t)\right]$$

<u>Teething problems:</u> shocks

(no viscosity, lack of a minimal length scale)

<u>Speculation:</u> Can one include quantum turbulence

in a meaningful averaged way?