Cold atoms

1: Bose-Einstein Condensation

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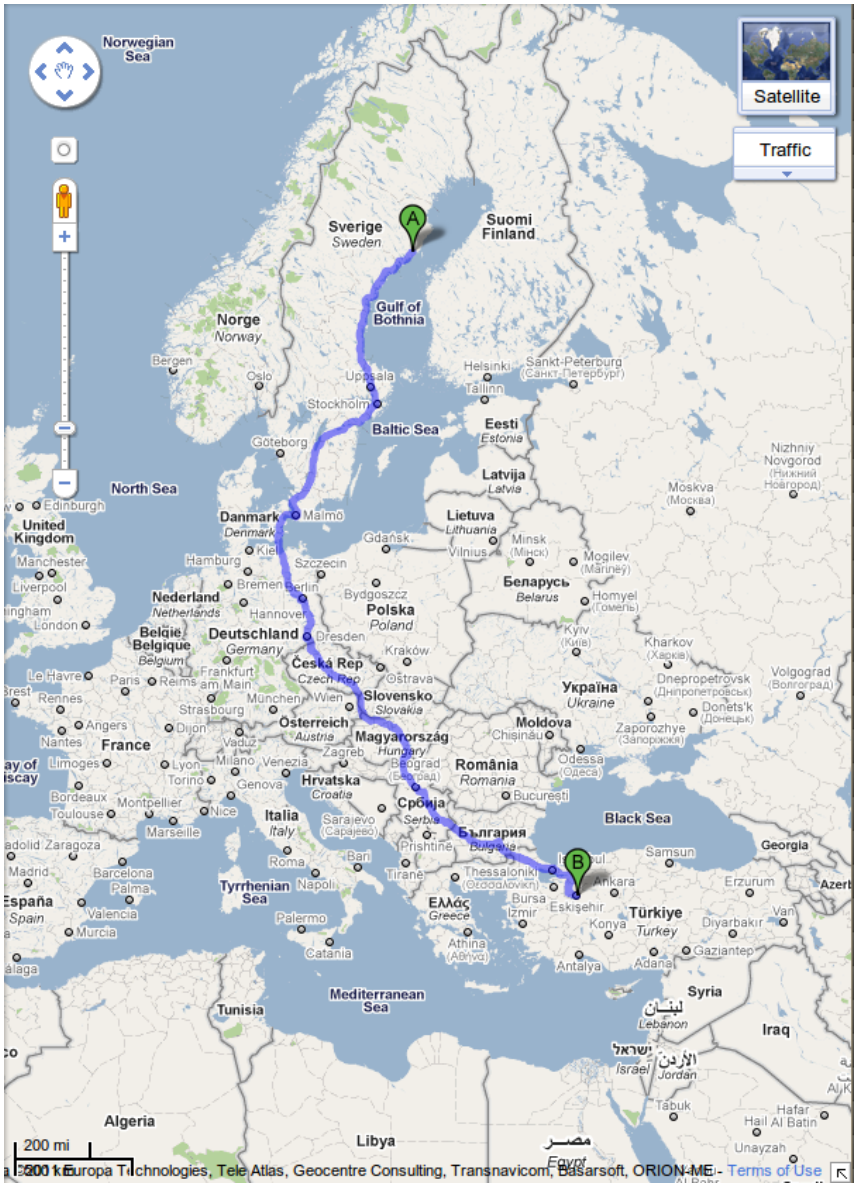
Umeå



114 000 inhabitants
Average age 37.9 years
Cultural capital of Europe 2014
400 km ski tracks
180 km bicycle paths
Umeå University with 35 435 students

Umeå University

Master programmes in:

- Computational Physics
- Condensed Matter Physics/Nanotechnology
- Theoretical Physics
- Optical Physics/Measurement Physics
- Quantum Mechanics/Quantum Technique
- Space Physics

Lectures

- 1: Bose-Einstein Condensation (today)
- 2: Quantum Hydrodynamics
- 3: Optical lattices

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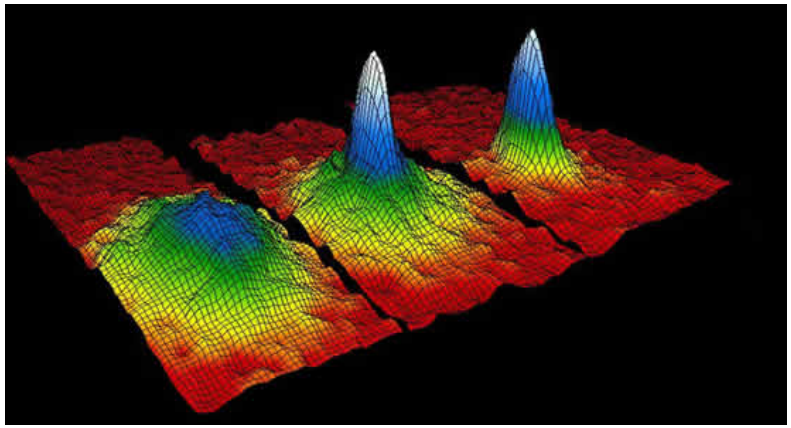
- Cooled to nK temperatures
- System size: a few μm
- Lifetime: seconds
- Detection: Photo of actual density!



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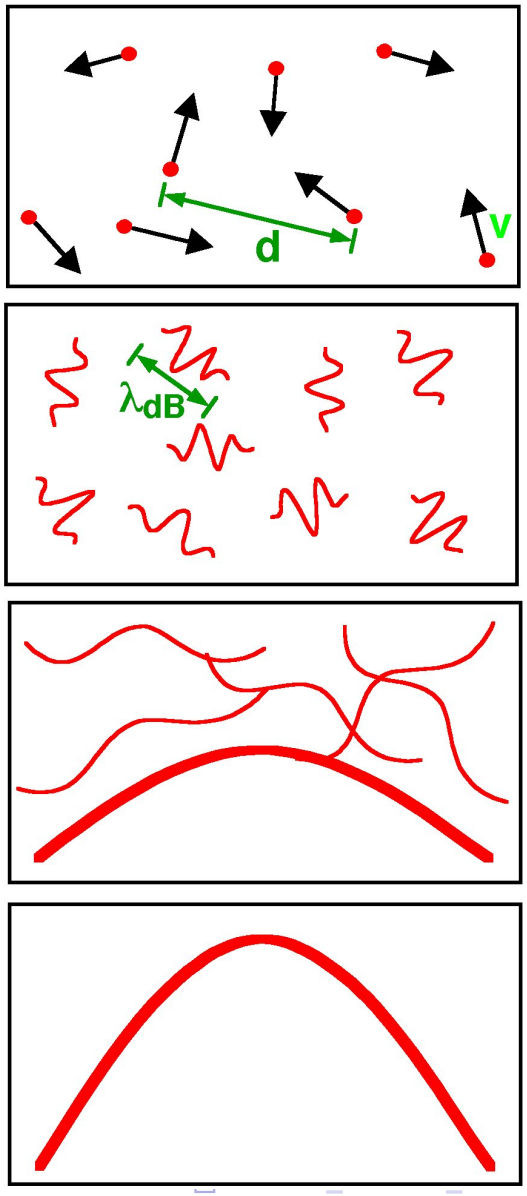

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- $3N$-dimensional space: the problem scales exponentially with number of particles. (L^{3N})
- Historically: Solid materials, nuclei, or liquid helium. Now have quantum *gases* - more versatile

(blackboard lecture)

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- 2007: BEC in polaritons in semiconductors (Snoke)

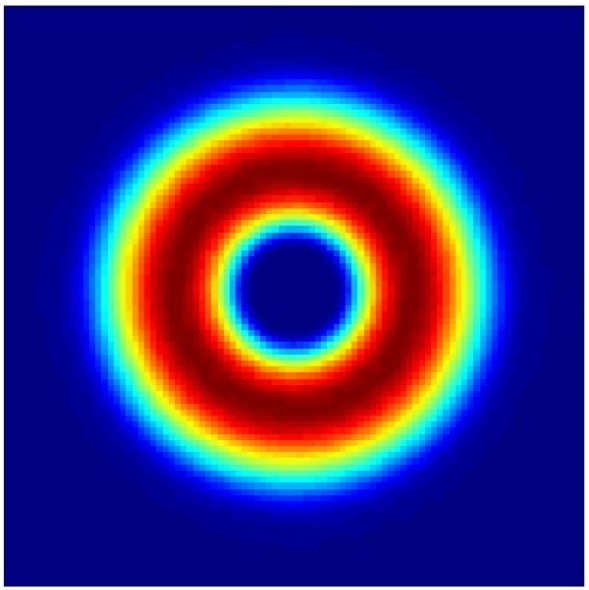
Gross-Pitaevskii equation

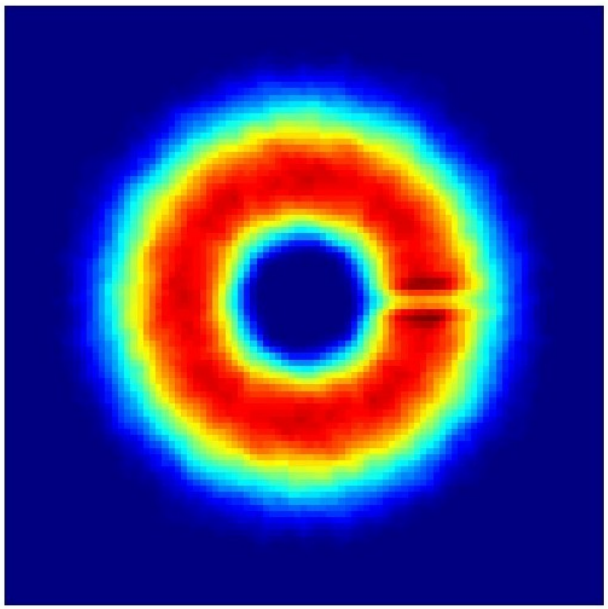
$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi + V(r)\Psi + U_0|\Psi|^2\Psi$$

GPE is used to simulate: ...

Gross-Pitaevskii equation

Ground state in various traps ...

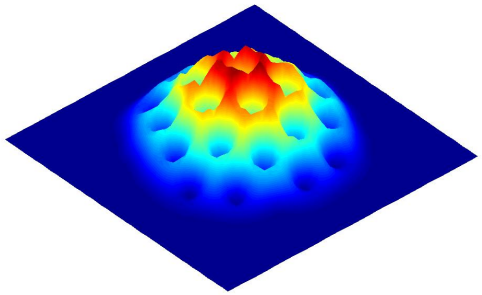




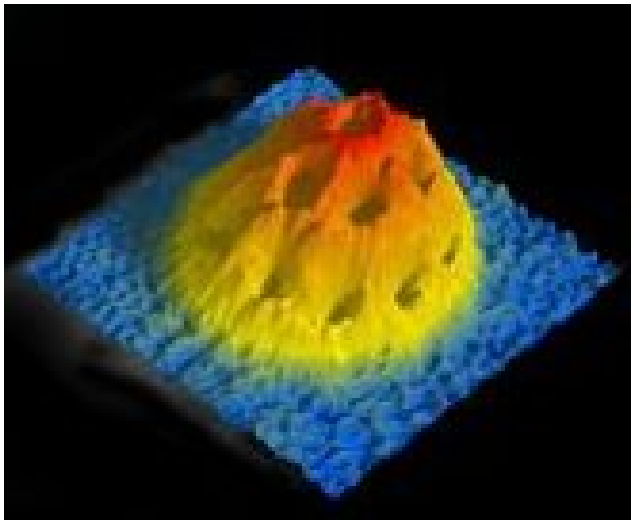
(BEC in a toroidal trap; work in progress)

Gross-Pitaevskii equation

... vortex lattices in rotated BECs ...



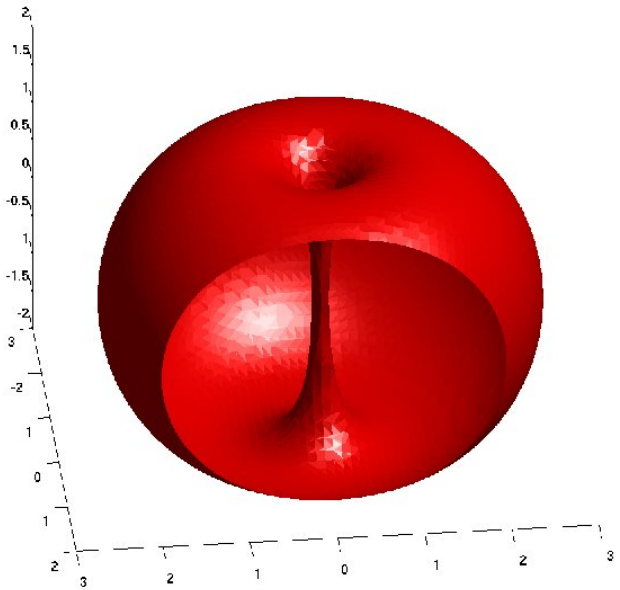
Theory

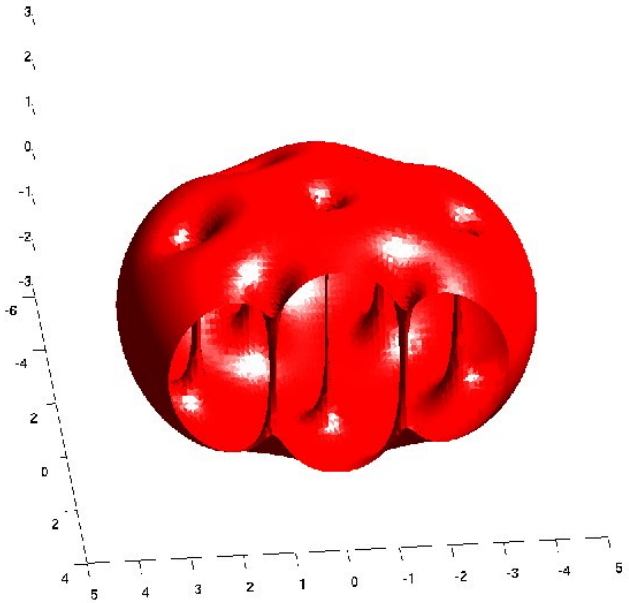


Experiment

Gross-Pitaevskii equation

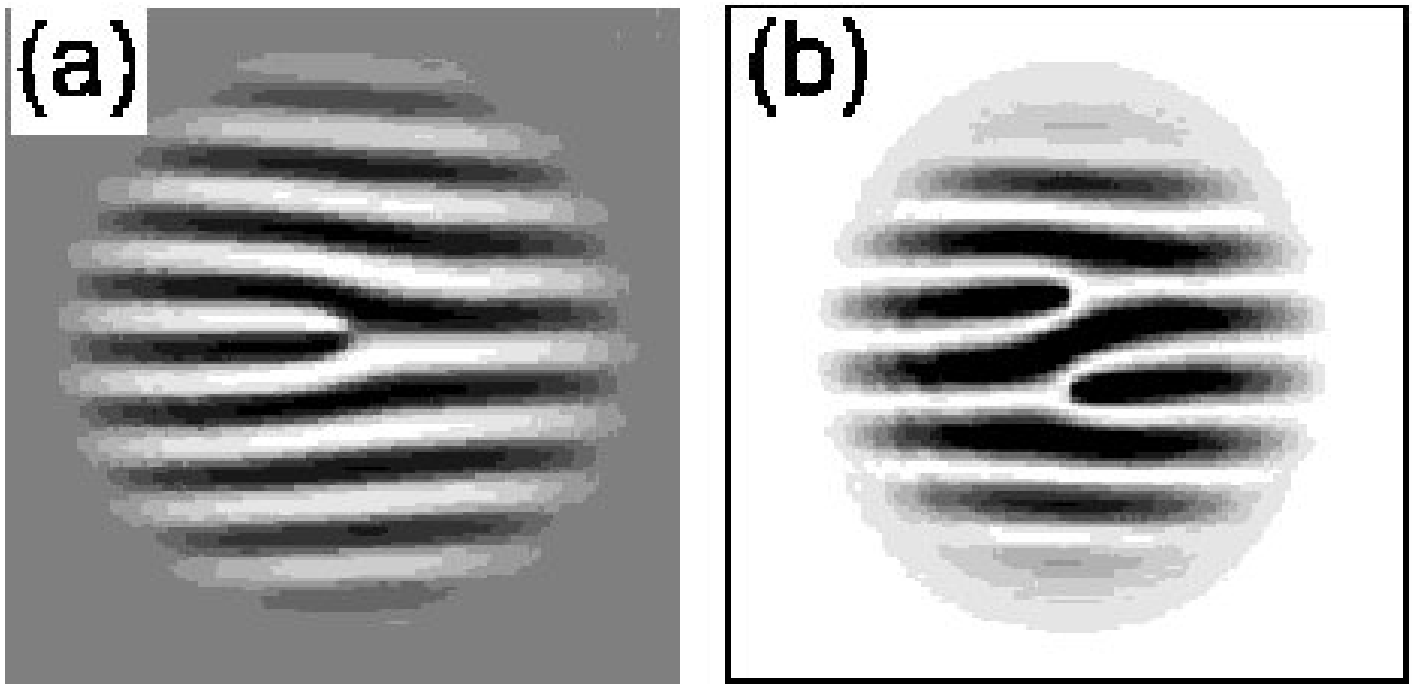
... More vortices (now in 3D) ...





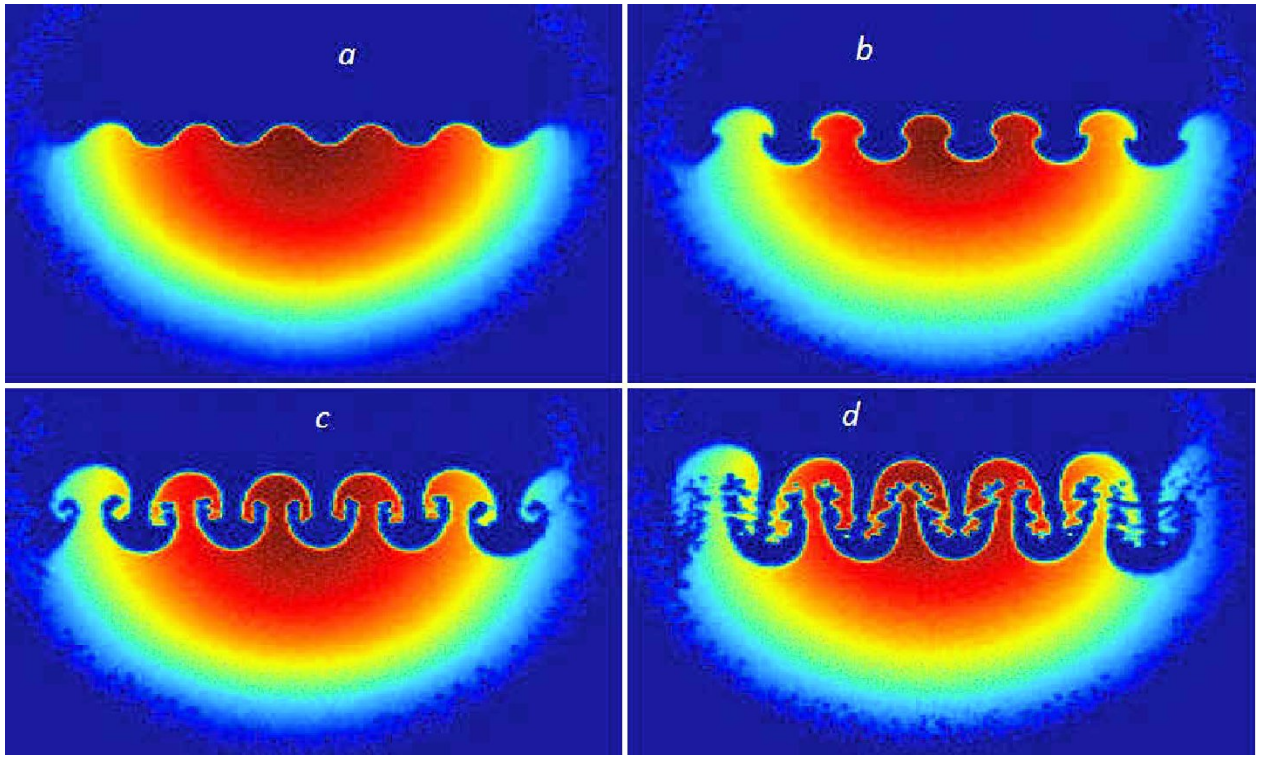
Gross-Pitaevskii equation

... coherence, correlations, interference fringes ...



Gross-Pitaevskii equation

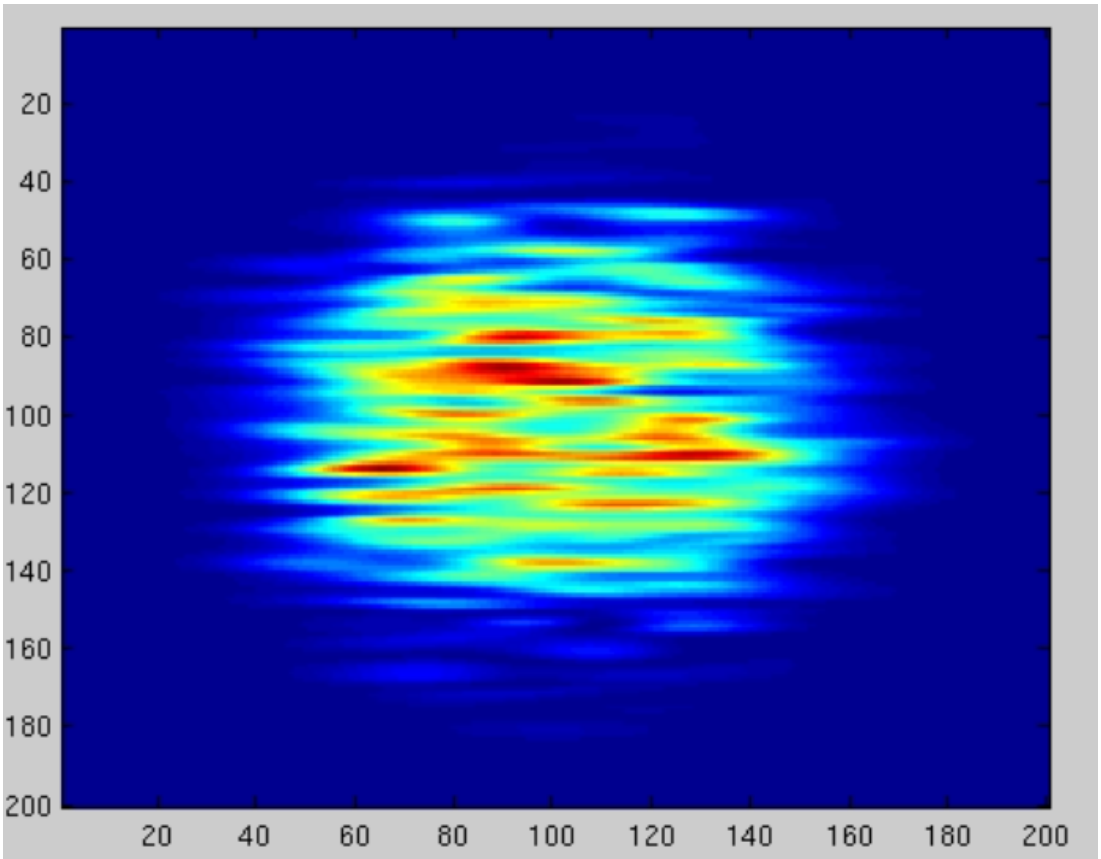
... systems of several condensates ...



Rayleigh-Taylor instability in an interface between two condensates
(More about this in Lecture 3)

Gross-Pitaevskii equation

...even finite-temperature physics and critical phenomena (with modifications)



End of lecture 1

Thank you for your attention