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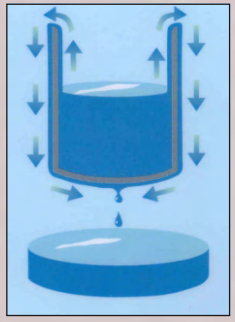
Superfluidity

Superfluidity

- Liquid helium boils at 4.2 K and has unique properties.
- Below T =2.176 K it becomes a superfluid.
- Boiling stops because of high heat conductance.
- Superfluids have zero viscosity and can flow through minute holes or superleaks *only a few atoms wide*.
- A superfluid film forms over all surfaces whose temperature is less than T .



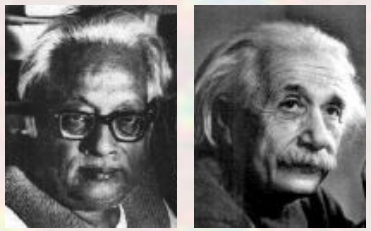
A beaker of superfluid empties spontaneously as the liquid flows over the side through the moving film.

- A Bose-Einstein condensate is a superfluid.

Ultra low temperature cryostat used for experiments on superfluids down to 100 K.

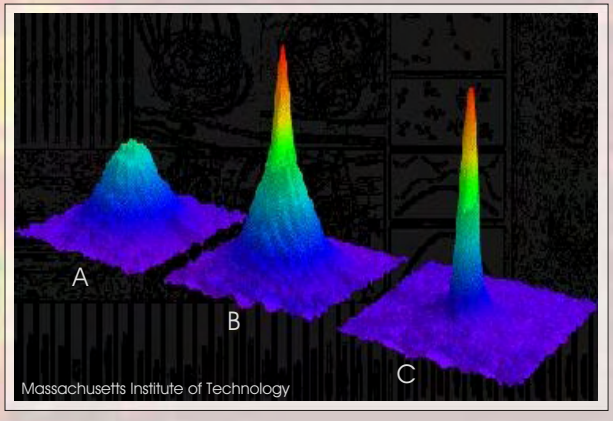
Bose-Einstein condensation

- The atoms in a normal gas have a range of speeds (the Maxwell-Boltzmann distribution).
- At low enough temperatures, the wave nature of atoms in a gas allows them to overlap and a transition occurs to a new phase of matter, the Bose-Einstein condensate (BEC). All the atoms then move with the same low velocity.



Bose Einstein

- Atoms are trapped in a small volume in a vacuum and cooled to ultra-low temperatures. The atoms are released from the trap and photographed as they expand, to measure their speed.



The profiles of expanding clouds of sodium atoms are shown. The height of the surface represents the number of atoms and the colour gives the speed (blue=high, green=medium, red=low velocities) for (A) Maxwell-Boltzmann distribution, (B) just below the BEC transition and (C) at the lowest temperatures.

Neutron stars are superfluid

The Crab Nebula resulted from a star that exploded - a supernova. The outer layers of the star were thrown violently into space, while the inner core collapsed to form a neutron star which rotates 30 times per second and emits intense bursts of light as a pulsar. The incredibly dense neutron matter should become superfluid at temperatures below 10^{11} K. Neutron stars cool below 10^{10} K soon after formation and are expected to have superfluid cores.

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