Superfluidity

- Liquid helium boils at 4.2 K and has unique properties.
- Below $T_\lambda = 2.176$ 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 $T_\lambda$.

A Bose-Einstein condensate is a superfluid.

Low Temperatures

- 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.
- 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.

Bose-Einstein condensation

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.