# Many-body phenomenology - syllabus

September 12, 2017

The scope of this course is to provide an introduction to quantum fluids, covering Bose-Einstein condensation, superconductivity, superfluidity, and Landagu-Ginzburg theory.

## 1 Part I: Bose-Einstein Condensation (BEC)

- Brief recap of Bose-Einstein statistics and BE distribution;
- BEC in non-interacting gases in three-dimensions;
- BEC in 2D;
- weak interactions and Gross-Pitaevski equation.

## 2 Part II: superfluidity

- experimental facts and phase diagram of bosonic He;
- Bogoliubov theory of the almost-ideal Bose gas;
- sound propagation and superfluid critical velocity;
- spectrum of bosonic He;
- off-diagonal long-range order and macroscopic wave-functions;
- flow circulation in the presence of a flux.

## 3 Part III: Ginzburg-Landau (GL.) theory of superconductivity

- experimental evidences of superconductivity and perfect diamagnetism;
- homogeneous GL theory;
- inhomogeneous GL theory and coherence length;
- GL theory in the presence of magnetic fields and flux quantization;
- type-II superconductors and Abrikosov lattices.

# 4 Part IV: Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity

- phonon-mediated interactions between electrons;
- two-particles problem: the Cooper pair;
- recap on coherent states;
- the BCS wave function;
- BCS gap equation.