

Physics 4410
Quantum Mechanics 2

Lecture 11

The Fermi gas

September 18, 2020

1. Consider a single electron in a three dimensional “box” of size L :

$$V(x, y, z) = \begin{cases} 0 & 0 \leq x, y, z \leq L \\ \infty & \text{otherwise} \end{cases} .$$

Find the allowed energy levels/states.

2. Now suppose there are $N \gg 1$ indistinguishable non-interacting fermions (ignore spin). Describe the ground state.

3. What is the total energy of the ground state?

4. Re-express answers in terms of electron density n . Account for spin.

Activity: Metals.

The canonical application of a Fermi gas is to the electrons in a metal.

- (a) Copper is a typical metal. Let's estimate the mass density to be 10^4 kg/m^3 . If each copper atom of mass $m \approx 10^{-25} \text{ kg}$ contributes one mobile electron, what is the number density n of mobile electrons?

(b) Estimate the Fermi energy E_F . The electron mass is $m \approx 10^{-30}$ kg. Compare to room temperature, $k_B T \sim 4 \times 10^{-21}$ J.