Phys635, MBQM II-Semester 2022/23, Tutorial 5, Wed 29.3.

Stage 1 Rest of tutorial 4: Do any questions from tutorial 4 that you didn't do earlier.

Stage 2 Fermi energy

(i) Can you think of electrons in an atom as degenerate Fermi gas? When do you expect this to be useful, when not so much?

(ii) Let us just assume we can use the concept. In the AMO lecture you would have learnt that the energy of an electron in a Hydrogenic atom (single electron, nuclear charge Z) is

$$E_n = -\frac{m_e e^4}{8\epsilon_0^2 h^2}\frac{Z^2}{n^2} = -13.6\text{eV}\frac{Z^2}{n^2} \tag{1}$$

where n is the principal quantum number. Find the Fermi-energy of Argon ($Z = 18$), assuming electrons do not interact.

Stage 3 Fermi pressure: Similar to how we found the 3D Fermi pressure in the lecture, find it in 2D and 1D. Compare the three cases and discuss.

Stage 4 Interacting Fermions:

(i) How does statistics affect atomic scattering? Which type of particles (Bosons or Fermions) has which partial waves?

(ii) What is a Fermi sea?

(iii) What is a Fermi liquid?

(iv) What are the excitations of a Fermi liquid?

(v) What is many-body dressing?

(vi) Make your own cartoon drawing of the ground state of an interacting Fermi liquid. How important is each contribution/basis state?