Fermion Gas

In Section 11.5, Moore states the Pauli Exclusion Principle. An immediate consequence of the principle is that it costs more and more energy to stuff additional fermions into a box, assuming the first ones occupied the lowest available energy states.

Of course, it costs more energy if they are charged, because like charges repel, but we are ignoring that. We just want to know the total energy cost to stuff N electrons into a box of length L. To warm ourselves up to the 3-dimensional case, let's do the 1-dimensional case first.

After doing our calculations, we will apply it to white dwarf stars. These are very dense stars containing only ordinary matter. We'll treat the white dwarf star as a box and simply estimate the energy required to have all its electrons in this box.

The Pauli Exclusion Principle

The principle is that "no two identical fermions can have exactly the same quantum state." If we are only dealing with electrons, as Pauli was in 1925, the principle is that "no two electrons can have exactly the same quantum state."

Defining Terms

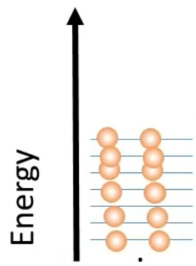
Defining our terms. We have been using fermion and electron interchangeably, but an electron is just one example of a fermion. Other examples of fermions are neutrons, protons, muons, and neutrinos. Any particle with spin 1/2 (or spin 3/2, 5/2, etc.) is a fermion.

Contrast this with the photon, which has spin 1. Particles with spin 0, spin 1 (or spin 2, 3, etc.) are called "bosons." As we were told in the lasing presentation, bosons "like" to be in the same state, where "like" means that there is an enhanced probability of them ending up in the same state. An example of a boson

1-D Fermion Gas

The highest energy level is called the Fermi level:

$$E_{max} = \frac{h^2 n_{max}^2}{8mL^2} = \epsilon_F$$



I show 2 electrons per level to account for the Spin degeneracy of each level

3-D Fermion Gas