One dimensional DGF

Calculate the Fermi energy of N spin $\frac{5}{2}$ Fermions in a one-dimensional infinite box potential of length L. Thus, redo the calculation for eqn 4.6. (Fermi energy in a box) of the lecture, changing the number of dimensions from 3 to 1.

The answer (using $\rho = N/L$ for the density ) is:

$$E_F = \frac{\hbar^2 \pi^2}{72m} \rho$$

$$E_F = \frac{\hbar^2 \pi^2}{36m} \rho^2$$

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$$E_F = \frac{\hbar^2 \pi^2}{36m} \rho^{2/3}$$

Spot the sentence that is correct.

The Fermi momentum is the mean momentum of the particles in a degenerate Fermi gas.

Fermionic cold atoms effectivel do not feel s-wave interactions, unless they are in the same spin state.

The Fermi temperature of an ideal Fermi gas in a 3D, isotropic, harmonic trap is higher than the condensation temperature of an equivalent Bose gas.

Fermi gases undergo a quantum phase transition to a degenerate Fermi gas below the Fermi temperature, where at a critical temperature $T_c$ , the Fermi-Dirac distribution function discontinuously changes.

Review the concept of degeneracy pressure from the lecture. From the following statements regarding a comparison of degeneracy pressure for ideal Fermions and what pressure would be there for ideal Bosons, pick the right one.

For Bosons in a box, the pressure at T=0 would be zero, for Fermions it is larger due to strong repulsive fermion-fermion interactions.

For Bosons in a box, the pressure at T=0 would be zero, for Fermions it is larger due to higher kinetic energies.

For Bosons in a box, the pressure at T=0 would be near zero (arising only from zero-point motion), for Fermions it is larger since more energetic quantum states also have to be occupied.

For Bosons in a box, the pressure at T=0 would be near zero (arising only from zero-point motion), for Fermions it is larger due to strong repulsive fermion-fermion interactions.

Fill in the blanks in the following statement (using assignments of numbers to words as listed) and click lock.

After the end of its nuclear fusion cycle, if the remnant of a star has a mass of $2M_{\odot}$, it will typically become a 2 (1=white dwarf, 2=neutron star, 3=black hole, 4=quasar), which is supported against gravitional collapse by 3 (1=not at all, 2=electron degeneracy pressure (dp), 3=neutron dp, 4=neutrino dp).

## Correct Answer

**Score:** 1

**Correct Answer:** Answers in order of appearance of blanks:
2
3

The energy gap is non-zero at all temperatures, but at the critical temperature the thermal energy begins to exceed it.

wrong

correct

## Correct Answer

**Score:** 0.5

**Correct Answer:** wrong

Fermion superfluidity and superconductivity both arise because of the nonzero minimal energy (gap) required to break a cooper pair.

wrong

correct

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

The superfluid/superconducing gap shrinks when temperature is increased, above a critical temperature, the gap and superfluidity disappears.

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

Cooper pairs in the basic class of superconducting metals are bound through effective phonon mediated interactions, involving lattice vibrations.

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

Cooper pairs in cold Fermionic gases, with atoms such as Li7, are bound through effective phonon mediated interactions.

wrong

correct

## Correct Answer

**Score:** 0.5

**Correct Answer:** wrong

In a two-body calculation, Cooper pairs form when considering them in the presence of a fully filled Fermi sea, but not in free space, when there are two particles and no others.

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

Cooper pairs are composed of two Fermions with equal magnitude of their spin but opposite spin direction.

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

For the existence of Cooper pairs require the attractive interaction strength to be larger than a critical value $U_{\mathrm{crit}}$ .

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** wrong

The superfluid/superconducing energy gap is smallest for excitations with momenta on the Fermi surface.

wrong

correct

## Correct Answer

**Score:** 0.5

**Correct Answer:** correct

Superconductivity arises since scattering an electron requires at least the Fermi energy.

correct

wrong

## Correct Answer

**Score:** 0.5

**Correct Answer:** wrong