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Physics 404 **HOMEWORK ASSIGNMENT #10** **Fall 2014**

The last, at last!!

The third quiz will be on Tuesday, Dec. 9 (one lecture later than in the original syllabus).

Due date: Thursday, Dec. 4 **Deadline:** Tuesday, Dec. 9

1. (7) 7.61 Low-temperature heat capacity of liquid ^{4}He. You do not need to repeat the derivation for phonons; just cite the relevant results and where they are modified here. It is convenient to consider one mole of ^{4}He, i.e. $N = N_A$. Note that we do not use the fact that ^{4}He becomes a superfluid below about 2 K.

2. (12) 7.64 Generalization of lattice vibrations to spin waves (and so phonons to magnons) Note that the integral in part a) is worked out in terms of by-now familiar special functions in eqn. B.36. The value of $\Gamma(3/2)\zeta(3/2)$ is about 2.315. In part b), the volume of a mole of Fe is 7.11 cm^3 (see table on p. 404). Hint: T_0 is about 4000K; find 2 more significant digits. In part c) you should find that the magnon and phonon contributions to C_V are equal at 2.17 K. You should further find that U is proportional to the same dimensional integral as in part a) but with 3/2 replacing 1/2 in the exponent of x in the numerator, so with value $\Gamma(5/2)\zeta(5/2) \approx 1.783$. In part d) just argue quickly that the number of magnons is proportional to the same integral with just 1 in the numerator (i.e. $n = 0$ in eqn. B.36. From the discussion of liquid ^{4}He we know that $\zeta(1/2) = \infty$, so you should be able to see this easily from the integral itself. This divergence implies that the material never magnetizes in the first place in 2D.

3. (10) 7.66 a,b,c Bose condensation of ^{87}Rb atoms. In part b), show that $k_B T_c \propto N^{2/3}\epsilon_0$ and find the proportionality constant. If you crank through part d) [not assigned], you would find that the ratio of N_0/N_1 is nearly 5 times as large as in part c).

4. (6) 7.70 a,b Heat capacity of gas of bosons. Compare your predicted value of $C_V(T_c)$ with that in Fig. 7.37. Take note of the result in part c).

5. (10) 7.71. Hints: Start with your result for $C_V(T)$ from the previous problem to find $S(T)$. You should then find $F \propto -N\,(T/T_c)^{3/2}\,k_B T$ and $p \propto \lambda_T^{-3}\,k_B T$. (You must verify these results and find the prefactors.)