YOUR NAME(s):_____

Physics 831 Quiz #8 - Friday, Nov. 17

Work in Groups of Three, and turn results in by Wednesday, Nov. 22, beginning of class

Using your results from Chapter 3, problem #2,

1. (10 pts) Beginning with the Van der Waals eq. of state,

$$P = \frac{\rho T}{1 - \rho/\rho_s} - a\rho^2,$$

   Find an expression for the free-energy density, $f(\rho, T) = -P + \mu\rho$. This requires finding $\mu(\rho, T)$.

2. (10 pts) Using $\mathcal{V}(\rho, T) = f - \mu_0\rho + P_0$, where μ_0 refers to the chemical potential for a uniform distribution of density ρ_0, plot $\mathcal{V}(\rho, T)/(a\rho_s^2)$ as a function of ρ/ρ_s for three temperatures ($T = 6a\rho_s/27,\ T = T_c = 8a\rho_s/27,\ T = 10a\rho_s/27$) and with $\rho_0 = \rho_c = \rho_s/3$. It might be helpful to change variables to $x \equiv \rho/\rho_s, t \equiv T/(a\rho_s), \tilde{\mu} \equiv \mu/(a\rho_s)$.

3. (10 pts) For $T > T_c$ find the parameter $A(\rho_0, T)$ used in landau theory,

$$\mathcal{V}(\rho, T) + \frac{1}{2}\kappa(\nabla\delta\rho)^2 = f - \mu_0\rho + P_0 + \frac{1}{2}\kappa(\nabla\delta\rho)^2 = \frac{1}{2}A(\delta\rho)^2 + \frac{1}{2}\kappa(\nabla\delta\rho)^2, \qquad \delta\rho = \rho - \rho_0.$$

4. (10 pts) Show that $A \to 0$ when $T = T_c$ and $\rho = \rho_c$.

5. (10 pts) Using expressions from Chapter 6, find the density-density correlation function for $T > T_c$,

$$\Gamma(r) = \langle \delta\rho(r = 0)\delta\rho(r) \rangle.$$

6. (10 pts) Find the fluctuation of the density $\chi_{\rho\rho} = \langle \delta Q \delta Q \rangle / V$ from $\Gamma(r)$.