Statistical Physics II Problem Set 3

Due: Tuesday, April 29, before the lecture

4. Depletion interaction

(8 points + 1 additional point)

a) Use the low-density approximation for $\Delta w(r_{12})$ given in the lecture,

$$\beta \Delta w(r_{12}) = -n \int f(r_{13}) f(r_{23}) \,\mathrm{d}^3 \mathbf{r}_3,$$

to calculate the effective interaction potential of two testing spheres with diameter σ_2 solved in a dilute fluid of hard spheres with diameter σ_1 . Consider in particular the marginal case $\sigma_1 \ll \sigma_2$ and sketch for it the potential with specification of the scale.

- b) Give a physical reason for the effective attraction of the testing spheres.
- c) Consider three testing spheres in the hard-sphere fluid. Which value may the ratio of the radii σ_1/σ_2 not exceed, so that the depletion interaction $\Delta w(r_{12})$ is presentable as pure pair interaction?
- d^{*}) Which qualitative changes do you expect for higher densities? (Sketch of $\Delta w(r)$ with specification of the scale!)

Hint: Consider at first the case $\sigma_1 = \sigma_2$, for which you know the qualitative form of g(r).

Total score: 8+1 points