Computational Manybody Physics

Problem Set #2

Due: Oct 25, in class

In this problem set, we will implement an exact-diagonalization for the frustrated Heisenberg chain,

$$H = J_1 \sum_{\langle ij \rangle} \mathbf{S}_i \cdot \mathbf{S}_j + J_2 \sum_{\langle\langle ij \langle\rangle} \mathbf{S}_i \cdot \mathbf{S}_j,$$

based on the exact-diagonalization source code for the Heisenberg chain.[1].

1. Using Lanczos method to find the energy of the ground state and lowest excited singlet ($S = 0$) and triplet ($S = 1$) for $L = 4, 8, 16, 20$. Locate the critical point $g = J_2/J_1 = g_c$ by the level crossing of the excited states.

2. Compute the spin correlation functions for $g = 0, g_c, 0.40, 0.45, 0.50$. Plot $C(N/2)(N/2)$ vs $1/N$.

3. Compute the dimer correlation functions for $g = 0, g_c, 0.40, 0.45, 0.50$. Plot $D(N/2) - D(N/2-1)$ vs $1/N$.

4. Show that at the Majumdar-Ghosh point $g = 0.5$, $D(N/2) - D(N/2-1)$ is size independent.

[1] See Prof. Anders Sandvik's website *http://physics.bu.edu/ sandvik/vietri/index.html*