Homework 7: Due May 24

Entanglement and Tensor Networks, Spring 2016, Prof. White

1. **Matrix Product Operators for the Hamiltonian**

(a) On pencil and paper, construct the MPO matrices for an Ising model with a transverse field:

$$H = \sum_{i=1}^{N-1} S_i^z S_{i+1}^z + h \sum_{i=1}^{N} S_i^x$$

Multiply the matrices together (still pencil) to show that it gives the correct Hamiltonian for four sites.

(b) In julia, construct the MPO for an 8 site Heisenberg chain with $h = 1$. Separately perform an exact diagonalization of this model to get the ground state, not in MPS form. Contract the MPO and the ground state to get $E = \langle\psi|H|\psi\rangle$, finding the same energy as in your exact diagonalization.

(c) Now convert the ground state to MPS form, and then contract the bra and ket of the ground state with the MPO for H to get the same E.

2. **Tensor renormalization group for the Ising model**

Implement TRG for the 2D classical Ising model, in either julia or ITensor. Print out the first 10 tensor singular values as a function of RG step for three temperatures: below T_c, at T_c, and above T_c.