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## Exercise Set 5

(Due date: Monday, June 27, 2016)

Exercise 5 (Cluster mean-field approximation for spin-models) (10 points) Consider the spin-1/2 Heisenberg model on the square lattice with antiferromagnetic exchange interaction  $J_1$  along the square and antiferromagnetic  $J_2$  along the diagonals.



- a) Calculate the classical energy per site as a function of  $J_2/J_1$  for checkerboard and stripe antiferromagnetic order. Make a plot.
- b) Implement the self-consistent cluster mean-field algorithm (CMFA). Use exact diagonalization for solving the cluster.
- c) Using CMFA on a  $2 \times 2$  cluster, calculate the energy per site as a function of  $J_2/J_1$  for the paramagnetic solution and checkerboard and stripe antiferromagnetic order. Make a plot. What do you observe compared to the classical limit?
- d) Use CMFA on a  $2 \times 2$  cluster to calculate the size of the magnetic moments as a function of  $J_2/J_1$  in the respective ground state configuration and plot it.

