Models on random graphs are interesting in both physics and computer science. In this course we will show how to solve statistical physics problem on such graphs. The course is intended to be self-contained and in particular no knowledge on replica theory is assumed.

The three first courses are introductory lectures on the physics on random graphs. They cover the physics on trees and then show how to deal with genuine random graphs, including in particular replica symmetric breaking effects. The goal is to bring the audience to a full understanding of the cavity method and the spin glass physics on random graphs. In particular, we will treat the p-spin problem (also called XOR-SAT in computer science) and the Potts glass problem (aka, the coloring problem).

1: From trees to random graphs:
   a) Why random graphs?
2: The cavity method I: clustering
   a) Reconstruction on trees and the planted ensemble
   b) Belief propagation and the clustering transition
   c) Clustering as the dynamic transition
   d) Planted ensemble and the Nishimori line.

3: The cavity method II: replica symmetry breaking (RSB)
   a) The cavity method at the 1RSB level.
   b) The clustering transition revisited
   c) The condensation transition and the spin glass phase.

The next three courses are intended to discuss application of the cavity method on some particular problems of physics and computer science. In particular, many recent developments as well as fundamental open questions will be presented.

4: Slow dynamics on random graphs: application in glassy physics and optimization problems
   a) The following state method for the adiabatic evolution
   b) Dynamics of spin glass problems
   c) Where are the really hard problems?

5: A lecture on the glass transition and the Nishimori line
   a) The glass transition as a melting problem: the analogies
   b) Melting on the Nishimori line: the glass transition IS a melting problem
   c) Open questions on the glass transition, and first-order transitions with disorder.

6: The Quantum cavity method: including quantum transverse field in the cavity method
   a) A quantum heat-bath algorithm for quantum spin problems
   b) The quantum cavity method.
   c) A variational ansatz