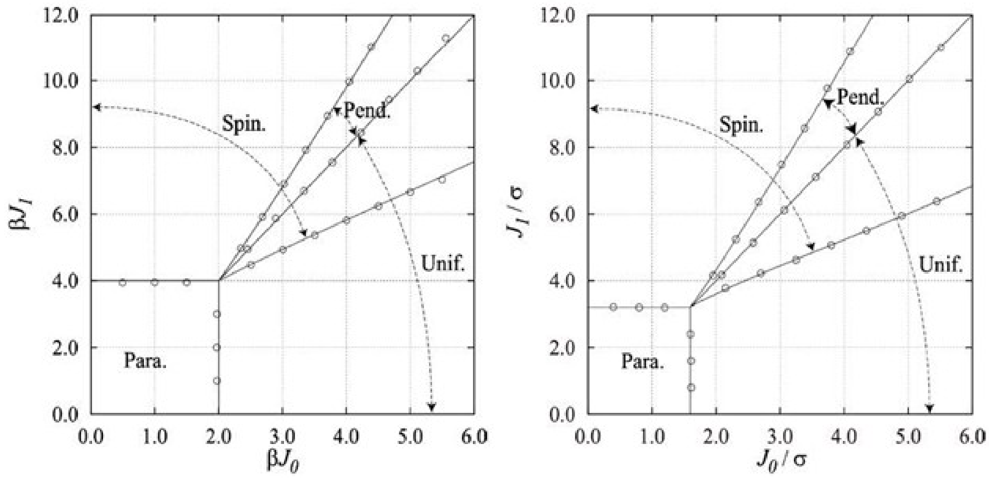
Unification theory of phase transitions in phase oscillators and the classical XY model

Tatsuya UEZU [Physics Course]

Phase Diagram



System on a circle. θ_i denotes the position on the circle, and the interaction is $J_{ij} = \frac{1}{N}(J_0 + J_1 \cos(\theta_i - \theta_j))$. Para. : Disordered phase. Unif.: Uniform phase.

Spin: Spinning phase. Pend.: Pendulum phase. Left panel: XY model. β is the inverse temperature. Right panel: Phase oscillator network. We take $g(\omega)$ as the Gaussian distribution with mean 0 and standard deviation σ .

The synchronization-desynchronization transition is considered to be a nonlinear phase transition and it is one of the important themes in non-equilibrium statistical physics and we have been studying phase oscillator networks.

Recently, for a class of infinite-range interactions, we found correspondence between the XY model with non-zero temperature and the phase oscillator network with distributed natural frequencies. Our purpose is to construct a unified theory which describes both models investigating conditions under which correspondence between the two models holds. In addition, we have been studying the classical XY model with an associative-memory-type interaction, and found a new type of solution, the so-called continuous attractor (CA), when the number of patterns is of order 1 irrespective of the system size.

The CA is considered to be able to realize the feature of real brains such as spontaneous retrieval and retrieval by an external stimulus.

We are now investigating the other conditions for the existence of the CA.

Keywords : Synchronization-desynchronization phase transition, Phase oscillator network, Classical XY model, Correspondence, Continuous attractor