30aYB-1 Bose-Einstein Condensation in Competitive Processes

Hideaki Shimazaki† and Ernst Niebur*
†Dept. of Physics, Kyoto University
*Dept. of Neuroscience, Johns Hopkins University

Competition plays a significant role in biological and social activities, and is the basis of evolution. We introduce an irreversible discrete multiplicative process as a generic model of competition [1], which satisfies three conditions at each time step:

1. A player's gain is proportional to its ability and to its gain at the previous step.

2. Players compete for finite resources.

3. A new player joins the game.

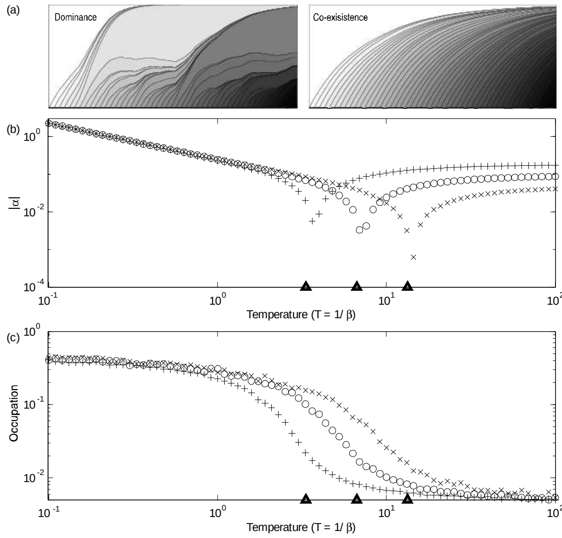

Fig1. (a) Temporal evolution of competitive processes at a low temperature (left) and a high temperature (right). (b) Absolute value of chemical potential analogue. (c) Occupation ratio by a dominant player.

In short, players with different abilities successively join the game and compete for finite resources. The model is based on *Malthusian population dynamics* with normalization at each step, and allows the introduction of new players, which is a hallmark of an open, nonequilibrium system. The model shows macroscopically observable changes in its behavior; at a singularity in the statistical distribution of the players' abilities, some of the most capable players become dominant over all others [Fig. 1]. To understand this nonequilibrium phase transition, we introduce a temperature analogue that parameterizes the ability distribution. We show that the emergence of dominant players and the evolutionary development of the system are described by the mathematical framework of Bose-Einstein condensation (BEC). Applied to biological competitions, BEC in an irreversible process provides theoretical grounds for *the principle of competitive exclusion* and the hypothesis of *punctuated equilibria*. Biologically plausible mechanisms that make the system *self-organizes* into the critical state will be proposed.

[1] Hideaki Shimazaki and Ernst Niebur, cond-mat/0303298