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Phenomenological Study on Spatial Coupling

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Abstract:

One of the major themes in statistical physics is to elucidate macroscopic properties of a system consisting of a large number of simple elements which are connected with each other. The Curie-Weiss model of ferromagnetism is an example of such systems, in which interconnections of Ising spin variables are simple. Models of spin glasses can also be regarded as such systems where interconnections bear randomness, yielding non-trivial complex macroscopic properties.

The concept of spatial coupling has recently been attracting attentions primarily in the context of coding theory, in that it offers a systematic means to realize channel coding schemes which saturate Shannon's theoretical bound (channel capacity) on achievable information transmission rate over a noisy channel. In view of statistical physics, on the other hand, a spatially-coupled system can be regarded as a system consisting of a large number of subsystems which are themselves complex but interconnected in a rather simple manner. If the subsystems are of a mean-field type, then it would be possible to give an abstract description of behaviors of such a system on the basis of the mean-field description of the subsystems.

In this talk we describe our recent phenomenological study on spatial coupling. We deal with a continuum limit of a spatially-coupled system which is represented in terms of a partial differential equation, and in particular study systems in which the subsystems are described by a double-well potential and thus bi-stable. In such systems, spatial coupling may allow states of the subsystems to escape from the meta-stable state to the stable state. Some conditions for the escaping have been discussed. We also briefly touch on applications of spatial coupling to the multiuser-detection problem in the code-division multiple-access (CDMA) systems.

Reference: Keigo Takeuchi, Toshiyuki Tanaka, and Tsutomu Kawabata, "Performance improvement of iterative multiuser detection for large sparsely-spread CDMA systems by spatial coupling," preprint available as arXiv:1206:5919 [cs.IT], 2012. --