Other transitions in statistical physics and beyond: from the liquid/gas transition to the representation of space in the brain

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Understanding the mechanisms by which space gets represented in the brain is a fundamental problem in neuroscience. The experimental discovery of so-called "place cells" and "grid-cells" (rewarded by the Nobel Prize in Medecine this Fall), encoding specific positions in space, provide essential elements in this context. How a spatial chart, that is, a relation between different points in space, may be built and memorized? In this talk, I will present a model involving binary neurons (either active or silent), making possible to store one or more spatial charts. In the case of a single map the model is equivalent to a lattice-gas system, and undergoes a phase transition for decreasing temperatures from a vapor phase to a liquid phase (Lebowitz-Penrose theory). When more maps are stored the model is an extension of the Hopfield auto-associative memory model, in which D-dimensional continuous attractors rather than fixed points are stored. The model may be solved with the help of the (non rigorous) techniques of the statistical physics of disordered systems, and shows a combination of ferromagnetic, paramagnetic, and glassy phases, depending on the control parameters. I will discuss the dynamical features of the system, with an emphasis on the transitions between maps, in relationship with recent teleportation experiments on living rats.