Statistical mechanics of heterogeneous interacting adaptive agents

We discuss a class of models of complex adaptive systems where a large number of agents interact for the exploitation of a large number of distributed resources. The prototype examples are the El Farol bar problem and the Minority Game, but many socio-economic, technological and natural systems - e.g. agents interacting over the Internet, the stock market and markets with a fixed supply, urban traffic or ecosystems to name a few - are of this type.

The complexity arises, in these systems, from the fact that agents are heterogeneous in the sense that each uses the resources in a different way. Agents have low rationality in the sense that they respond in an adaptive way to their complex environment by selecting one of a finite number of possible behavioral rules.

Statistical physics offers a range of quite sophisticated tools to tackle these complex problems. We discuss in detail this approach which reveals a quite interesting and non-trivial variety of collective phenomena.

In particular, we find that naive agents who act as if they were interacting with Nature (the equivalent of price taking behavior in a competitive market) do not reach Nash equilibria. A minimal deviation from such naive behavior - which amounts to agents accounting for their impact on the aggregate - is enough to ensure convergence to Nash equilibria.