Opening of a postdoctoral position on the project
Statistical Mechanics of Learning

Scope of the project: Computers are now able to recognize people, to tell a dog from a cat, or to process speech so efficiently that they can answer complicated questions. This was still impossible only a decade ago. This progress is largely due to the development of the artificial "deep-learned neural networks". Nowadays, "deep learning" is revolutionizing our life, prompting an economic battle between internet giants, creation of a myriad of start-ups and inspires many to dream about artificial intelligence in a way that previously only appeared in science fiction novels. As attractive and performant as this is, however, many agree that deep learning is largely an empirical field that lacks a theoretical understanding of its capacity and limitations. The algorithms used to "train" these networks explore a very complex and non-convex energy landscape that eludes most of the present theoretical methodology in statistics. The behavior of the dynamics in such complicated "glassy" landscape is, however, similar to those that have been studied for decades in the physics of disordered systems such as molecular and spin glasses.

In this project we pursue this analogy and use advanced methods of disordered systems such to develop a statistical mechanics approach to deep neural networks. The goal is to bring theoretical understanding of the principles behind the empirical success of deep neural networks. We use analytic and algorithmic methods (replica, cavity method, message passing) originating in the research of spin glasses and the physics-based strategy of studying exactly solvable simplified models. We analyze their phase diagrams, associated phase transitions and related algorithmic implications (e.g. hard phases and new algorithms). On the way to our main goal of building theory of deep learning we encounter many fascinating problems of current statistics, machine learning, data and network science to which our approach contributes. We also pursue mathematically rigorous establishment of the methodology. The project is firmly based in statistical physics but flies towards various topics in computer science, signal processing, complexity theory, information theory, machine learning, combinatorics etc.

We are looking for **candidates with one of the following backgrounds** (or a combination of the two) to join the team and work on one or more of many sub-problems related to the project.

(1) PhD in statistical physics of disordered systems such as glasses, spin glasses, or interdisciplinary applications. Experience and interest in both analytical (such as the replica and the cavity method) and numerical techniques (message passing, Monte Carlo). Interest in computer related issues and/or machine learning welcome.

(2) PhD in fields related to machine learning, information theory, signal processing, data processing, computer science, statistics with a strong interest to learn more about methods from statistical mechanics.

We offer a two year postdoctoral contract within the French CNRS, with the standard CNRS salary and benefits (full healthcare coverage for postdoc and his/her dependents, generous vacations, 16-weeks fully paid maternity leaves, free schooling from age 3 etc.). The group is based in Institute of Theoretical Physics (IPhT) in CEA Saclay (about 20 km south of Paris, well connected by frequent commuter train and buses). IPhT is one of the best and largest laboratories of theoretical physics in Europe. The group currently has the PI, 2 PhD students and one postdocs and is about to grow. We work in close collaboration with Florent Krzakala (ENS Paris) and his group (we have a joint working group, a journal club, and the seminar series Golosino) and with a number of other colleagues in the Parisian area and around the world. The position will start in 2018 (precise starting date is flexible).

Interested applicants are invited to send their questions, **CV and a statement of motivation and interest in the *S*MiLe project** to the PI Lenka Zdeborová. Candidates are expected to have read some of my recent publications to get an idea of the type of work that is expected. Applications are receivable till **November 30, 2017**.

Contact: Lenka Zdeborová (lenka.zdeborova@gmail.com), informal inquiries are welcome.