# AlphaZero meets active matter physics

Master's thesis project

We are looking for a highly motivated MSc student to join our Soft Matter Theory group (Prof. Dr. Benno Liebchen) at the Technical University of Darmstadt for a project in the area of smart active particle navigation.

Active matter comprises motile agents such as bacteria, crawling cells or synthetic colloidal microswimmers, locally injecting energy into the system. One of the most fundamental challenges for microorganisms is to navigate through hostile and complex environments comprising toxins and obstacles in search of nutrients and other chemicals which they need to survive. With the advancement in the design of artificial microswimmers and their potential for future nanomedical applications, the need for understanding and replicating path planning strategies, which biological microswimmers have learned throughout evolution, has become a crucial part in the puzzle of creating future smart nanorobots.

In this project we aim to use recently developed deep reinforcement learning (RL) methods with integrated planning (originally designed for the famous algorithms which could beat world leading chess and Go players [AlphaGo and AlphaZero]) for the first time in active matter physics! As a part of the project, deep RL agents will be trained to go beyond the current understanding of optimal collection strategies for microswimmers. Thus, the prospective student will have the opportunity to become familiar with state of the art deep RL methods and to use them to tackle key problems at the forefronts of modern non-equilibrium physics. The project also leaves room for complementary pen and paper calculations based on optimal control theory.
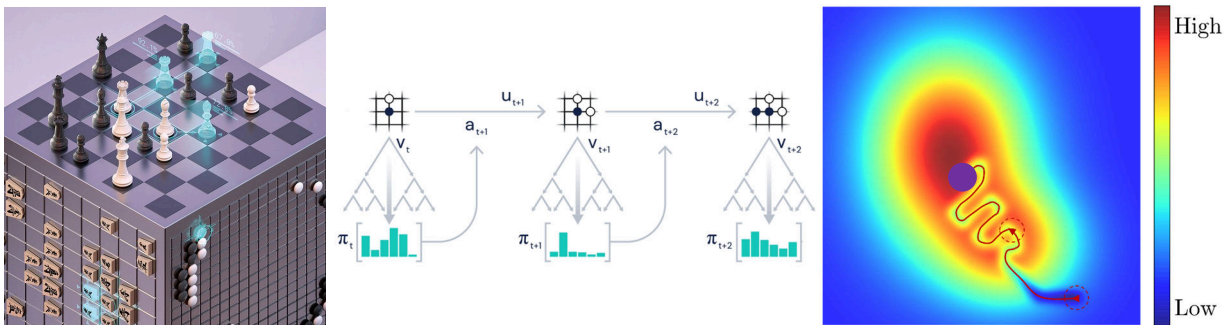
Requirements:

- Very good Bachelor's degree, ideally with a focus in theoretical and or computational physics.
- Prior experience of programming in Python (or good programming skills in other languages).
- Very high motivation for learning topics in active matter physics as well as in artificial neural networks, reinforcement learning and dynamic programming.
- Any previous experience in working with a deep learning framework (such as Pytorch or TensorFlow) will be a plus but is not necessary and can be learned while working on the project.

If you are interested to work on this project together with Mahdi Nasiri and Benno Liebchen, please contact us via email (mahdi.nasiri@pkm.tu-darmstadt.de, with a cc to benno.liebchen@pkm.tu-darmstadt.de) with a few lines of motivation.