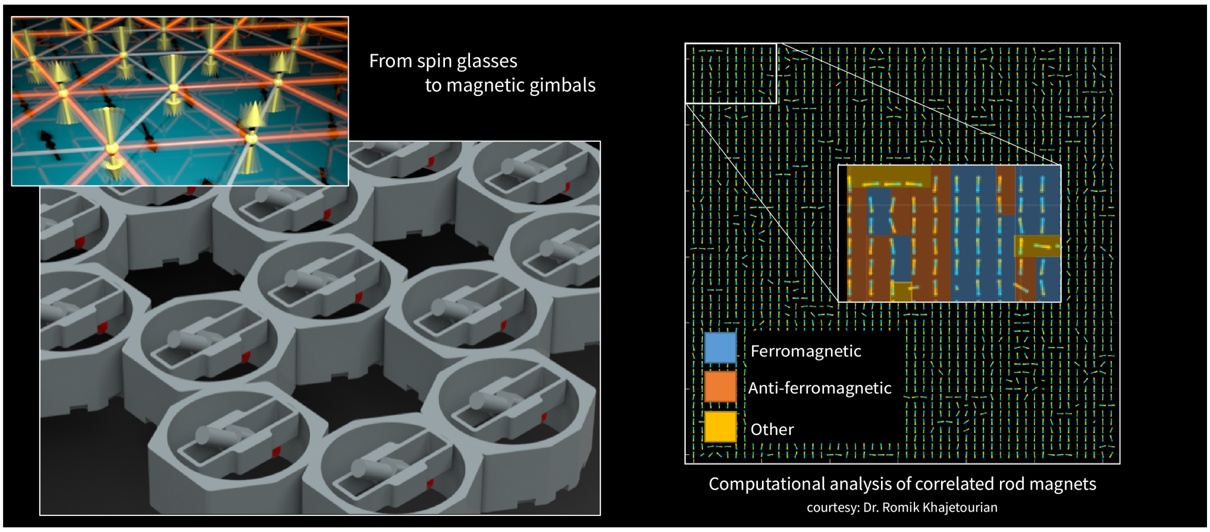
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Mechanics & Materials Laboratory
Prof. Dr. Dennis M. Kochmann
www.mm.ethz.ch

Bachelor/Master thesis projects
Reconfigurable magnetic metamaterials – Macroscopic analogues of magnetically-ordered materials



Background: A major focus within our research group is in the realization of reconfigurable metamaterials i.e., materials that can be designed to present complex, non-linear and transient response to an external stimulus. A specific example involves guiding non-linear waves i.e., propagating disturbances in the material whose kinetics are not governed by linear elastic behavior. By controlling the mechanisms that drive these "waves", we essentially design the rate and anisotropy of energy transfer across such metamaterials. One such metamaterial derives inspiration from material systems with magnetic order e.g., ferromagnets, anti-ferromagnets and spin glasses. The functionality of these materials originates from the magnetic dipole moment of the atomic lattice, and how these dipoles interact with each other on a longer length scale. This project seeks to develop macroscopic analogues of such materials using arrangements of rigid rod magnets constrained to rotate in three dimensions. While the interaction between two magnets is straightforward, an array of multiple such magnets can give rise to interesting transient properties that are difficult to model.

Project description: This project will focus on experimentally realizing and characterizing this class of magnetic metamaterials. Rod magnets mounted on a 3D-printed gimbal with three degrees of rotation form the fundamental unit cell of our magnetic metamaterial. The first phase of this project will involve the development of an experimental rig and image processing code to image and compute the three-dimensional rotation of a single magnet in space. During the second phase, the student will build one- and two-dimensional periodic patterns of these magnetic unit cells to observe and quantify the correlated dynamics of our macroscopic magnetic dipoles. In combination with a theoretical framework developed previously in our group, the student will design and test macroscopic analogues of functional magnetic materials such as ferromagnets, anti-ferromagnets and spin glasses. The experimental framework will extend to incorporate spatially-localized "defects", and their effects on non-linear information transfer across re-configurable magnetic metamaterials.

Thesis advisors:
Dr. Dotan Ilssar, Dr. Vignesh Kannan
Mechanics & Materials Lab, Department of Mechanical and Process Engineering
Email: dilssar@ethz.ch , kannanvi@ethz.ch