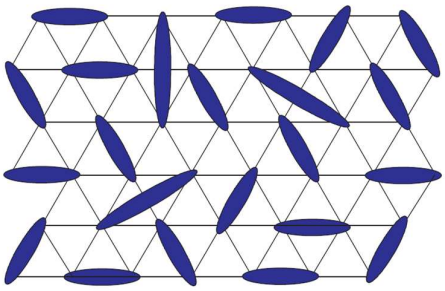
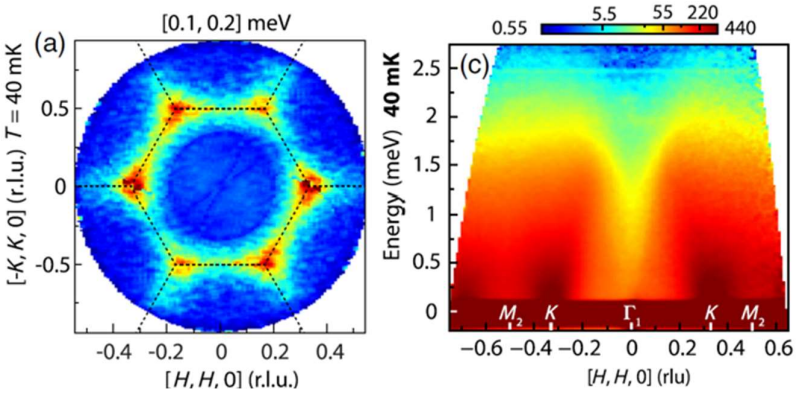
PhD in experimental condensed matter physics:

Exotic Quantum Phases and Excitations in Frustrated Triangular Lattice Magnets

Quantum materials with strong magnetic frustration have intrigued physicists for decades. They exhibit unusual magnetic characteristics due to the quantum behavior of electrons and offer huge potential for next-generation quantum electronic devices. One interesting quantum spin phenomenon that has fascinated theorists for 50 years is the quantum spin liquids, the liquid-like spin states in analogy with normal liquids such as water. In such exotic magnetic states, the spins are strongly interacting with their neighbors and produce locally correlated patterns, but they remain fluctuating down to zero temperature and the tendency towards long-range spin order is disrupted by quantum fluctuations. Theories have predicted that the spins in quantum spin liquid states are highly entangled, which is essential for future applications such as quantum computing. In recent years, a dazzling variety of quantum spin liquid phases have been predicted in quantum magnets with different frustrated lattices such as the triangular lattice. They possess fundamentally distinct characters and can be either resonating-bond-solid type, gapped or gapless, chiral, or topological in nature. Their elementary excitations are also highly non-trivial, involving Majorana quasiparticles, gauge fluxes, spinons, etc. To date, the true quantum spin liquid states have not been identified experimentally. Existing candidate materials suffer from all kinds of complexities, the most notorious being "unwanted" additional terms in the Hamiltonian and structural inhomogeneity. The race is on to find better experimental realizations of the most interesting quantum spin liquid models and to investigate them in the laboratory.



A resonating valence bond type quantum spin liquid state on a triangular lattice proposed by theory.



Measured magnetic excitation spectrum of a triangular-lattice quantum spin liquid candidate.

The present PhD project at the Neutron Scattering and Magnetism Group, Laboratory for Solid State Physics, Physics Department, ETH Zurich, aims to apply state of the art experimental techniques to investigate exotic quantum phases and excitations in several carefully chosen triangular lattice quantum spin liquid candidates. It will involve a detailed characterization of the novel materials using magnetometry, magneto-dielectric and magneto-thermodynamic measurements at mK-temperatures and high magnetic fields, as well as X-ray, muon spin rotation and neutron diffraction studies. The main thrust will be an extensive spectroscopic investigation. Inelastic neutron scattering studies will be carried out at state of the art large-scale user facilities in Switzerland, France, UK, and the USA.

The successful candidate is expected to be actively involved in every phase of the project, and eventually take over a leading role in its realization. No prior experience in muon spin rotation measurements or neutron scattering is required, but a **solid background in laboratory work** is indeed a must. Since the project is based around rather complex concepts in modern quantum solid state physics, a solid **theoretical base in quantum mechanics, statistical physics and solid state physics** is **absolutely essential**. Good computer skills are a plus. For ETH students, it is possible to start with a Masters project that may later develop into a PhD study.

For further information please contact Prof. Dr. Andrey Zheludev at *zhelud@ethz.ch*.
Please also visit the group's web site: *http://www.neutron.ethz.ch/*.