In the last decades the performance of computers has rapidly increased to the point in which a standard smartphone outperforms supercomputers from 1960’s by a few orders of magnitude. Miniaturization of integrated circuits allowed to equip computers with much higher computational resources, while lowering their prices, energy consumption, and size. This electronic revolution was made possible by the advances in materials science and engineering. However, while the computational demand grows, the current microprocessor technology approaches a point in which the size of an individual transistor is so small that the quantum mechanical phenomenon of electron tunneling makes the further downscaling of transistors is not possible - the technology hits the barrier of atomic size.

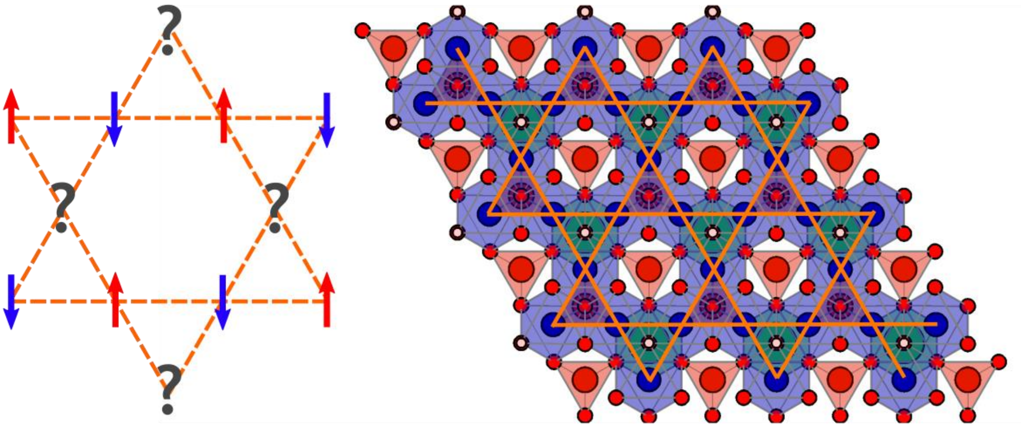

Figure 1: Left: spins with antiferromagnetic interactions (neighbors having opposite orientation) on a kagomé lattice are frustrated – they cannot be arranged in a way that all the pairs are satisfied. Right: kagomé network of Co^{2+} ions (blue) in $BaCo_3(VO_4)_2(OH)_2$ – one of the compound studied in the project.

The way to increase the computational performance without further decrease in transistor size is to use quantum computing. In this concept a two-state (0 or 1 corresponding to “false” and “true”) bit is replaced by a “q-bit” (quantum bit) which state can be a superposition (a mix of 0 and 1). In order to build a practical quantum computer, one has to have a material in which quantum state has direct, easy to observe effects on macroscopic properties such as magnetization or electrical resistivity. One kind of such system is a quantum spin liquid (QSL) in which atomic magnetic moments remain fluctuating down to the absolute zero temperature due to an interplay between the crystal structure and spin interactions resulting in the so called magnetic frustration (Fig. 1). There are theoretical proposals of exploiting the QSL materials to form q-bits and to store information.

The goal of the project is to study the physical properties of several Cu- and Co-bearing compounds. Large part of them are synthetic analogues of minerals, found eg. at fumarolic exhalates of the Tolbachik volcano (Kamchatka peninsula, Russia). Complex interplay of chemical composition an bonding, magnetic interactions and crystal structure distortions results in exotic magnetic properties of these systems. Our task is to, at least partially, understand these mutual interactions.

The project will be done in collaboration with scientist at the Johns Hopkins University in Baltimore, MD, USA, Clemson University, Clemson, SC, USA, and McMaster University, Hamilton, ON, Canada.