Low dimensional quantum magnets: what are they and how are they affected by pressure?

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The properties of quantum magnets are determined by the interactions of ions in a material. By measuring the bulk, we gained insight on how the individuals ions behave.

Recently quantum devices have become an increasingly fascinating and promising technology. To keep up with these advances, new materials and new phenomena need to be explored and understood so that we have replacements ready when "modern" technology eventually become obsolete. The phenomenon of interest in this work is quantum magnetism. Superconductors, quantum computers and spintronics are just a few technologies that will benefit from quantum magnetism.

Classically, magnetism is about collective behavior of a large group of atoms. Quantum magnetism instead describes the magnetic properties of individual atoms. More specifically we looked at "paired up" magnetic atoms. Surprisingly enough, the properties of individual atoms and pairs can be observed through measurements of the whole material.

The goal was to study the effect of pressure on quantum magnets. We estimated the pair-creating interaction in these magnetic materials. We did this both for a regular measurement and after applying pressure to the material. We found that applying pressure changes the strength of the interactions but not the nature of the interactions.

The reason why pressure is of interest is because pressure can change the properties of materials. For example, everyone knows that water boils at 100 degrees Celsius. This is however not true on Mount Everest where water boils at 70 degrees Celsius. This is because the (atmospheric) pressure is lower on Mount Everest than on most inhabited places on Earth. Another example is that applying pressure on ice can cause it to melt. While water is a simple molecule with two atom-types as building blocks, the quantum magnets studied in this project consist of many different types of atoms that have their own effects on the overall material. Therefore, the explanations to explain these magnetic materials isn't always straightforward.

The quantum magnets were first synthesized since they are rather complicated structures and can't be bought. After making the magnets and looking at how purely they were made, we continued to study two.

The magnetic material studied most thoroughly was used in ancient China as a pigment known as *Han purple* or *Chinese purple*. It was already produced in 800 BC and later used as decorative paint on the famous terracotta warriors from 220 AD. However, this special material disappeared in the following 17 centuries, only to be discovered together with the terracotta statues in 1974. It would take another two decades before chemists knew how to make it again. Today we consider this ancient pigment as a potential messenger of our path to the future of quantum magnetism.