High-Field ESR study on Molecular-based Nano-magnets

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High-field ESR is one of the most important experiments to study the magnetic properties of the molecular-based nano-magnets, and is widely applied for single-molecule magnet such as Mn_{12}. It is because the result is usually understood by a trivial analysis considering its discrete energy levels, thermal population and mixing. Followed by a brief introduction on the application of high-field ESR to some molecular-based nano-magnets, we report our latest study on the polyhedron cluster system $Mo_{72}M_{30}$ (M=V, Cr and Fe) and its ground state are revealed.

As shown in the figure below, $Mo_{72}M_{30}$ (M=V, Cr and Fe) is a polyhedron magnetic cluster where 30 magnetic ions form an icosidodecahedron (a high symmetric polyhedron with triangular and pentagonal network) structure. Each magnetic ions are antiferromagnetically coupled, and the number of magnetic state is as huge as $(2S+1)^{30}$, where S is the local spin on each corner. The energy state is highly degenerated due to the strong frustration, thus, its ground state and magnetic properties are in question.

For M=Fe compound, where S=5/2, we found some anomalies in the magnetization, specific heat, and ESR anomalies similar to low-dimensional system as well. Namely, the ESR peak shows significant shifts and broadenings. The peak shift indicates the development of short-range correlation inside the polyhedron while the broadening of linewidth might be the indication of critical slowing down of the spins towards T=0. Hence, classical ground state with a local magnetic moment (spin freezing state) is proposed for the M=Fe compound. On the other hand, quantum ground state (singlet ground state) is revealed from ESR and susceptibility measurements for M=V (S=1/2) compound. For M=Cr (S=3/2), which belongs to the intermediate state, we found also some anomalies in the magnetization, however, ESR mode seems to disappear in the low-magnetic field region. We think that M=Cr compound has also a classical ground state similar to M=Fe, but its ground state seems to be very fragile with the magnetic field.