Understanding the Role of Structural Distortion on the Magnetic Behavior of Cobalt Vanadate Kagomé System

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Antiferromagnetic properties of Kagomé staircase systems have been quite successfully studied by Heisenberg's model in recent years and explained some of the rare physical phenomena such as Quantum excitations and coupled frustrated spin configuration [1,2]. The cobalt vanadate $Co_3V_2O_8$ (*CVO*) system is considered as a unique compound among the family of Kagomé staircase systems $M_3V_2O_8$ (*M = Co, Ni, Cu,* and *Mn*). These compounds are known to exhibit significant geometrical frustration and multiple field-induced phase transitions over wide magnetic fields and temperatures which can be easily mapped on the *H-T* plane [3]. In the current work, we report on such unique magnetic properties of *CVO* in the form of bulk poly crystallites that arise from structural distortion. Crystal structure analysis reveals the formation of the orthorhombic structure of space group: *Cmca* with lattice parameters a = 6.05 Å, b = 11.5 Å, and c = 8.31 Å in which the edge-sharing CoO_6 octahedral layers lies in the *a-c* plane, separated by *V-O* tetrahedra aligned along the *b*-direction. The relatively large interlayer to intralayer ratio, ($d_2/d_1 \sim 1.9$) and the indirect interlayer *Co-O-O-Co* superexchange path suggest a strong two-dimensional magnetic character of the compound. Consequently, the magnetic properties are dominated by intralayer coupling of Co^{2+}-*O*-Co^{2+} interactions. However, unlike other Kagomé lattice systems, these corner-sharing Kagomé layers in *CVO* are not flat instead they are buckled, resulting in a Kagomé staircase geometry (as shown in Figure 1). Such buckled Kagomé layers cause inequivalent superexchange interactions, and the anisotropic magnetic coupling in the "staircase" magnetic layers which contribute to the reduction of geometric frustration in *CVO*. This results in the appearance of multiple temperature-dependent magnetic phase transitions [3]. To get a greater insight into its magnetic structure we employed both molecular field theory (*MFT*) and the Heisenberg linear chain (*HLC*) mode and estimated the nearest neighbour exchange interaction J_{EX} which turns out to be ~ 2.32 K and 2.24 K obtained from *MFT* and *HLC* methods, respectively. A detailed comparative study of the magnetic structure between the *CVO* and its isostructural systems will be presented.

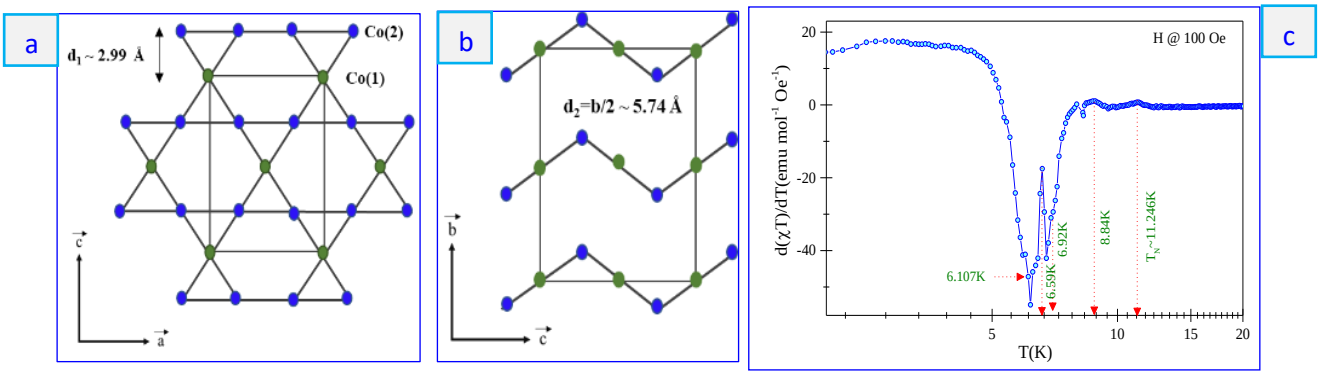

Figure 1: (a) The crystal structure of CVO as viewed down the crystallographic c-axis. There are two Co sites: the Co (1) cross-tie at the apex of the triangles and the Co (2) sites. (b) Edge-on view of the Kagomé staircase. (c) Multiple magnetic transitions seen from the temperature dependence of differential magnetic susceptibility data (d(χT)/dT vs. T).

References:

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