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Structure, disorder, and magnetism in Herbertsmithite, a kagomé Heisenberg antiferromagnet

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Geometric frustration of magnetic ordering on triangle-based lattices is thought to be one avenue to inducing macroscopic quantum states in electron systems. Due to the triangular arrangement of ions, it is impossible to satisfy all nearest-neighbor interactions simultaneously. This “frustration” suppresses classical magnetic long-range order and is thought to be capable of resulting in novel quantum states such as various resonating-valence-bond or “spin-liquid” ground states for a two-dimensional (2D) $S = 1/2$ antiferromagnet. However, “structurally perfect” frustrated materials are rare; frequently, materials undergo a structural distortion at low temperature, relieving the magnetic frustration and giving rise to a classical ground state. In this talk, I will present recent structural and property studies of the 2D candidate spin-liquid material “ $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$.” Using X-ray scattering differences at elemental absorption edges and an improved analysis technique, I will show that there is no Zn occupation of the intralayer Cu sites within the kagomé layer, as previously reported; however there is Cu present on the Zn intersite, leading to a real structural formula of $(\text{Zn}_{0.85}\text{Cu}_{0.15})\text{Cu}_3(\text{OH})_6\text{Cl}_2$. Combined with recent pulsed high field magnetic measurements, the lack of Zn mixing onto the kagomé lattice sites lends support to the idea that the electronic ground state in “ $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$ ” and its relatives is non-trivial.