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Multiple Coulomb Phase in the Fluoride Pyrochlore CsNiCrF6

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Frustrated magnets are a particularly promising class of materials for studying emergent phenomena in condensed matter. The construction of field theories describing the correlations and excitations of spins on a pyrochlore lattice is a prominent example. Such theories are typically based on a Coulomb phase, in which a non-divergent field with power-law correlations encodes the correlation function. Well known possibilities include emergent magnetostatics with monopoles in classical spin ice, or emergent electrodynamics with magnetic photons and charges in quantum spin ice. However, other types of Coulomb phase based on different degrees of freedom are possible, and this work describes an investigation of a material in which Coulomb phase correlations are simultaneously present in both the structural and magnetic degrees of freedom. We present the results of neutron and x-ray scattering experiments on the structural and magnetic correlations, and magnetic dynamics in CsNiCrF6, and basic models of the correlations, which show that this is a crystalline solid with highly correlated disorder that can be described by three Coulomb phases: a charge ice, displacement ice, and pyrochlore Heisenberg antiferromagnet-like spin system [1]. CsNiCrF6 is a member of a large class of compounds (AMM'F6), and these may be of broader general interest - correlated structural disorder should be a feature of many materials with mixed cations, and may well help to develop novel functionalities, such as new thermoelectrics [2].
[1] Fennell *et al.*, Nature Physics **15**, 60 (2019)
[2] Overy *et al.*, Nature Communications **7**,10445 (2016)

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