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Hidden Order in Spin-Liquid $Gd_3Ga_5O_{12}$ JOSEPH PADDISON, School of Physics, Georgia Institute of Technology, USA, and Department of Chemistry, University of Oxford, UK, and STFC-ISIS, UK, HENRIK JACOBSEN, Nanoscience Center, University of Copenhagen, Denmark, and European Spallation Source, Sweden, OLEG PETRENKO, Department of Physics, University of Warwick, UK, MARIA TERESA FERNÁNDEZ-DíAZ, Institut Max von Laue - Paul Langevin, France, PASCALE DEEN, Nanoscience Center, University of Copenhagen, Denmark, and European Spallation Source, Sweden, ANDREW GOODWIN, Department of Chemistry, University of Oxford, UK — Frustrated magnetic materials are promising candidates for new states of matter because lattice geometry suppresses conventional magnetic dipole order, potentially allowing non-dipole ("hidden") order to emerge in its place. However, an atomic-scale model of a hidden-order state has been difficult to obtain because microscopic probes are not directly sensitive to hidden order. We use a combination of neutron-scattering experiments and reverse Monte Carlo refinements to develop a model of the spin-liquid state in the canonical frustrated magnet $Gd_3Ga_5O_{12}$. We show that this state exhibits a hidden order which has three unusual properties. First, it is a collective phenomenon, in which multipoles are formed from ten-spin loops. Second, it is long-range, with a diverging correlation length. Third, it is a consequence of the interplay between antiferromagnetic spin correlations and local planar magnetic anisotropy, which allows it to be indirectly observed in our neutron-scattering experiments.

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