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James C. McGroddy Prize for New Materials Talk: Geometrically Frustrated Materials

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Geometrical frustration occurs when interacting degrees of freedom do not "fit" into the lattice that they occupy and, as a result, are under-constrained at low temperature. While the early ideas behind geometrical frustration originate in Wannier's triangular antiferromagnetic Ising model and Anderson's resonating valence bond model, they are broadened here to define an entire class of magnetic materials whose structures are based on triangular or tetrahedral units. When the degree of misfit is high, conventional long range order is suppressed and thermodynamic spectral weight is pushed to energies much lower than the mean field value. Out of this low energy spectral weight, new states of matter are found to emerge experimentally, such as spin liquid on the kagome lattice and spin ice on the pyrochlore lattice. The concept of geometrical frustration can be broadened beyond magnetism to describe a frustrated soft mode that can lead to persistent negative thermal expansion and giant dielectric constants. A brief review will be given of recent work on excitations in frustrating lattices, including the prediction of, and evidence for, magnetic monopoles in spin ice, and the relevance of frustrated hopping for topological insulators.