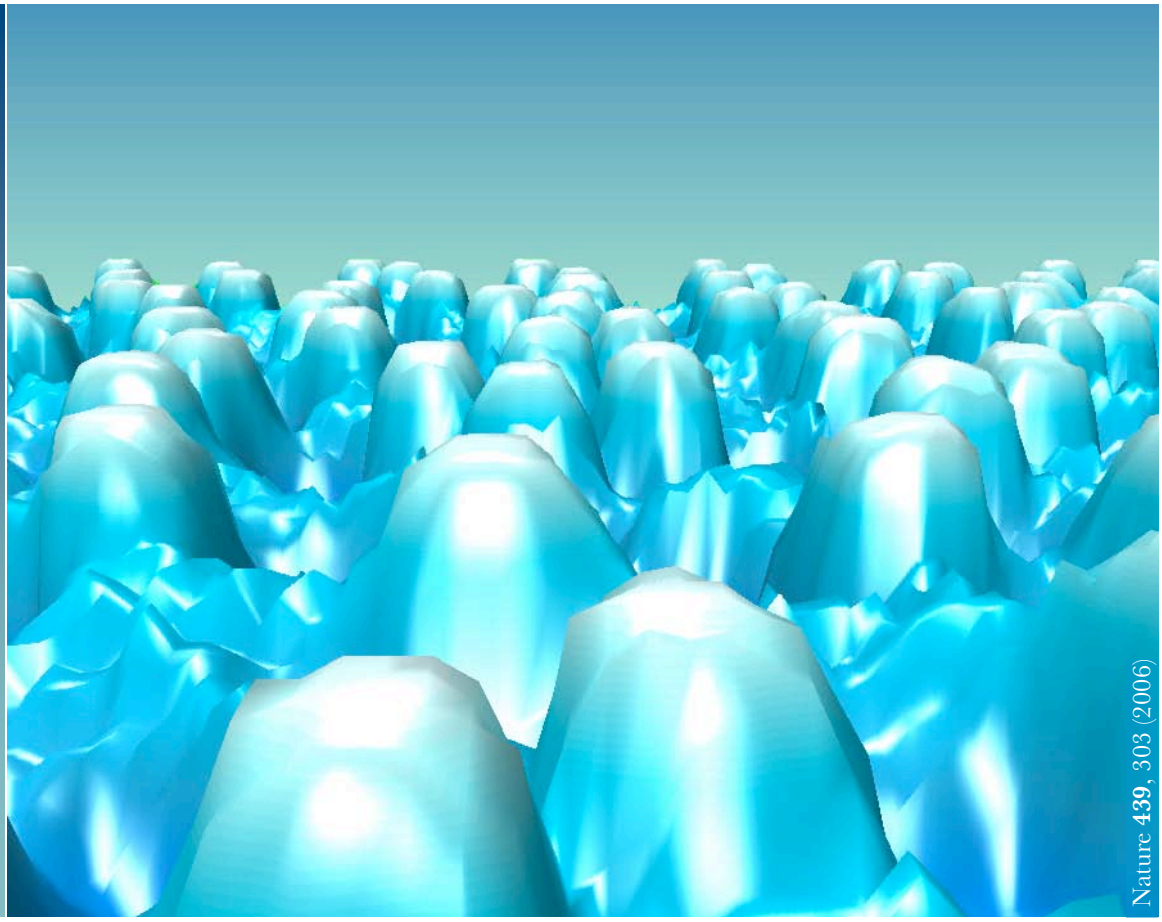
FRUSTRATION

Penn State MRSEC

False-color rendering of the pattern of magnetic poles in a frustrated lattice of two-dimensional spin ice.



Nature **439**, 303 (2006)

Magnetic frustration by design
spins can't always get what they want

Seed program

Frustration is not only a state of mind, but also a state of matter wherein the interactions among different subunits cannot all be satisfied. Ordinary water ice is highly frustrated: there are many many different ways in which the protons within the lattice of ice can be arranged, and all are equally good (or bad, depending on your point of view).

Because of this so-called macroscopic ground state degeneracy, water ice has finite entropy, even at absolute zero. The "spin ices" are a class of magnetic materials wherein the spins of electrons play the same role as the protons in water ice: they have a huge multiplicity of arrangements at absolute zero, all of which have the same energy and none of which is preferred over the others.

A research team in the Penn State MRSEC, in collaboration with Chris Leighton at the University of Minnesota, has produced a new form of frustrated matter, a two-dimensional lattice of magnetic islands. These islands act as tiny bar magnets arranged on a carefully designed lattice so that the north and south poles of the bars cannot all align so as to optimize their mutual interactions. Instead they are frustrated, and are trapped within a set of distinct but energetically equivalent configurations.

Not only does this work open a door to designable and resolvable frustrated systems, but with magnetic storage media ever-shrinking in size, these mechanisms of frustration may find application in designing media wherein the bits of information can be closer together without interfering. This project, begun as a MRSEC seed, is now funded by the Army Research Office.