Printing circuits on rare nanomagnets puts a new spin on computing
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Spin glasses are a way to think about material structure mathematically. Being free, for the first time, to tweak the interaction within these systems using electron-beam lithography makes it possible to represent a variety of computing problems in spin-glass networks, Saccone said.

At the intersection of engineered materials and computation, spin-glass systems are a type of disordered system of nanomagnets arising from random interactions and competition between two types of magnetic order in the material. They exhibit “frustration,” meaning that they don’t settle into a uniformly ordered configuration when their temperature drops, and they possess distinct thermodynamic and dynamic traits that can be harnessed for computing applications.

"Theoretical models describing spin glasses are broadly used in other complex systems, such as those describing brain function, error-correcting codes or stock-market dynamics," Saccone said. "This wide interest in spin glasses provides strong motivation to generate an artificial spin glass."

The research team combined theoretical and experimental work to fabricate and observe the artificial spin glass as a proof-of-principle Hopfield neural network, which mathematically models associative memory to guide the disorder of the artificial spin systems.

Spin glass and Hopfield networks have developed symbiotically, one field feeding off the other. Associative memory, whether in a Hopfield network or other forms of neural networks, links two or more memory patterns related to an object. If just one memory is triggered—for instance, by receiving a partial image of a face as input—then the network can recall the complete face. Unlike more traditional algorithms, associative memory does not require a perfectly identical scenario to identify a memory.
The memories of these networks correspond to ground states of a spin system and are less disturbed by noise than other neural networks.

The research by Saccone and the team confirmed that the material was a spin glass, evidence that will allow them to describe the properties of the system and how it processes information. AI algorithms developed in spin glass would be "messier" than traditional algorithms, Saccone said, but also more flexible for some AI applications.


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