on which camp you reside in. If you favour the many-worlds or Bohm interpretations, then the PBR theorem shouldn't trouble you in the least — the wavefunction is an explicit part of your ontology (in many-worlds, it is your ontology), so the ontic state uniquely determines ψ.

Likewise if you adhere to the shut-up-and-calculate philosophy or the Copenhagen interpretation (which I think of as shut-up-and-calculate minus the shutting-up part) then the PBR result shouldn't trouble you. You don't have an ontology: you consider it uninteresting or unscientific to discuss reality before measurement. For you, ψ is indeed an encoding of human knowledge, but it's merely knowledge about the probabilities of various measurement outcomes, not about the state of the world before someone measures.

If, like Roger Penrose, you believe quantum mechanics itself is just an approximation to some deeper theory, then again PBR shouldn't trouble you. For in that case, you're free to adopt a shut-up-and calculate attitude about ψ, while also holding out hope that the yet-undiscovered deeper theory will grant you your ontology.

But if you think that the rules of quantum mechanics are fine and the wavefunction is merely a summary of human knowledge about underlying objects that are not themselves quantum states — then, and only then, the PBR theorem spells big trouble for you. In this case, you have two choices: you can either deny the PBR tensor product assumption, or you can change your belief. Personally, I'd opt for the latter. ❐

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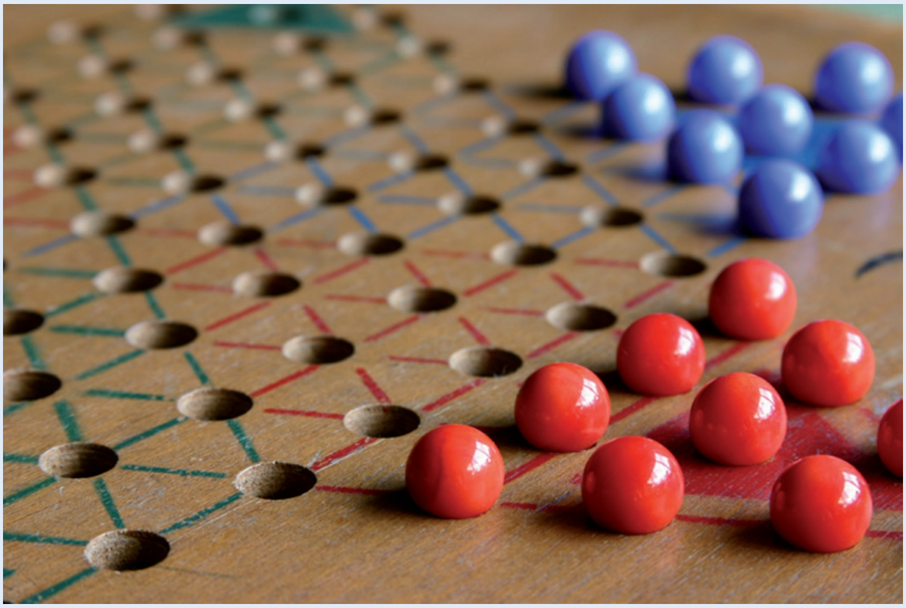
QUANTUM SIMULATION

Toy model

To understand the physics of complicated systems, physicists choose to work with simplified models that can be easily manipulated and observed: from eighteenth-century orreries to the twentieth-century Feynman quantum simulator, the toy models may have grown in complexity, but the principle remains the same. Now, using cold trapped ions — as though in a game of marbles on a lattice board — Joseph Britton and colleagues demonstrate such a toy model for quantum magnetism (*Nature* **484,** 489–492; 2012).

Spin frustration is one of the tricky problems in quantum magnetism that cannot be efficiently tackled using computer simulation. The challenge is to find the minimum-energy configurations for spins on a triangular lattice — however, the lattice geometry forbids the simultaneous minimization of the interaction energies at a given site. In analogy with marbles on a board, the problem corresponds to trying to fill the board with blue and red marbles such that no marble has two neighbours of the same colour.



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An alternative to this difficult computation is to actually construct a triangular lattice of interacting spins and have them evolve into various configurations. This can be done by trapping neutral atoms in periodic optical potentials; but, although the method is elegant, inducing the required type of interactions between the atoms is not straightforward. Ion interactions, on the other hand, are stronger and easier to control.

Britton *et al.* trapped hundreds of beryllium ions using electric and magnetic fields. The laser-cooled ions crystallized into a two-dimensional triangular lattice structure — an ion 'marble' at each site, with its electronic ground and excited states representing the 'colour': spin up or spin down. Using a pair of off-resonance laser beams, the researchers excited the collective motion of the ions. Then, through the entanglement of the ions' motion and their electronic states, this excitation could be translated into an effective ion–ion Ising-type interaction.

Several proof-of-concept experiments on spin interactions and quantum phase transitions have already been performed by other researchers, using few ions. But Britton and colleagues' work using hundreds of ions has created a new playground in which to explore quantum magnetism, far beyond simple computable scenarios.

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