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### **Engineering Ferromagnetism with Shaken Optical Lattices<sup>1</sup>**

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Conventional methods of quantum simulation rely on kinetic energy determined by free particle dispersions or simple sinusoidal optical lattices. Solid state systems, by contrast, exhibit a plethora of band structures which differ quantitatively, qualitatively, and even topologically. To what extent does this variety explain the many electronic phenomena observed in these materials? Here we address this question by subjecting an otherwise simple Bose superfluid to a customized band structure engineered by dynamically phase modulating (shaking) an optical lattice. The engineered dispersion contains two minima which we associate to a pseudospin degree of freedom. Surprisingly, in such a system the Bose superfluid exhibits many new behaviors. The pseudospin develops a ferromagnetic order, which can lead to polarization of the entire sample or to sub-division into polarized domains. The excitations of the system also exhibit the roton-maxon structure associated with strong interactions in superfluid helium. I will also discuss recent progress on engineering further exotic behavior.

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