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Emergent periodic and quasiperiodic lattices on surfaces of synthetic Hall tori and synthetic Hall cylinders YANGQIAN YAN, Department of Physics and Astronomy, Purdue University, SHAO-LIANG ZHANG, School of Physics, Huazhong University of Science and Technology, SAYAN CHOUDHURY, QI ZHOU, Department of Physics and Astronomy, Purdue University — Synthetic spaces allow physicists to bypass constraints imposed by certain physical laws in experiments. Here, we show that a synthetic torus, which consists of a ring trap in the real space and internal states of ultracold atoms cyclically coupled by Laguerre-Gaussian Raman beams, could be threaded by a net effective magnetic flux through its surface—an impossible mission in the real space. Such synthetic Hall torus gives rise to a periodic lattice in the real dimension, in which the periodicity of density modulation of atoms fractionalizes that of the Hamiltonian. Correspondingly, the energy spectrum is featured by multiple bands grouping into clusters with nonsymmorphic symmetry protected band crossings in each cluster, leading to braidings of wavepackets in Bloch oscillations. Our scheme allows physicists to glue two synthetic Hall tori such that localization may emerge in a quasicrystalline lattice. If the Laguerre-Gaussian Raman beams and ring traps were replaced by linear Raman beams and ordinary traps, a synthetic Hall cylinder could be realized and deliver many of the aforementioned phenomena.

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