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A Bose-Einstein condensate (BEC) on a synthetic Hall cylinder: quantum transport, emergent lattices, and topological effects CHUAN-HSUN LI, YANGQIAN YAN, SHIH-WEN FENG, SAYAN CHOUDHURY, DAVID B. BLASING, QI ZHOU, YONG P. CHEN, Purdue University — Interplay between matter and gauge fields in physical spaces with nontrivial geometries can lead to unexpected phenomena. However, most experimental studies in atom-based quantum systems have focused on spaces with relatively simple geometries. Here, we realize a BEC on a synthetic cylindrical surface (composed of a real spatial dimension and a curved synthetic dimension formed by cyclically-coupled atomic spin states) subject to a net radial synthetic magnetic flux. A lattice with a topological band structure emerges on such a Hall cylinder but disappears in the 2D plane counterpart. Applying a force to the BEC allows for studying its transport in such a lattice. We observe Bloch oscillations of the BEC with doubled period of the band structure, analogous to traveling on a Mobius strip in the momentum space, reflecting the topological band crossings protected by a nonsymmorphic symmetry. We further apply a symmetry-breaking perturbation to induce a topological transition with gap opening at the band crossings. We also study possible effects of inter-particle interactions in the quantum transport. Our work opens the door to engineering synthetic gauge fields in synthetic spaces with nontrivial geometries and observing intriguing phenomena inherent to such spaces.

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