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Filling constraints for spin-orbit coupled insulators in symmorphic and non-symmorphic crystals HARUKI WATANABE, Massachusetts Institute of Technology, HOI CHUN PO, ASHVIN VISHWANATH, UC Berkeley, MICHAEL ZALATEL, Station Q — We determine conditions on the filling of electrons in a crystalline lattice to obtain the equivalent of a band insulator - a gapped insulator with neither symmetry breaking nor fractionalized excitations. We allow for strong interactions, which precludes a free particle description. Previous approaches that extend the Lieb-Schultz-Mattis argument invoked spin conservation in an essential way, and cannot be applied to the physically interesting case of spin-orbit coupled systems. Here we introduce two approaches, the first an entanglement based scheme, while the second studies the system on an appropriate flat Bieberbach manifold to obtain the filling conditions for all 230 space groups. These approaches only assume time reversal rather than spin rotation invariance. The results depend crucially on whether the crystal symmetry is symmorphic. Our results clarify when one may infer the existence of an exotic ground state based on the absence of order, and we point out applications to experimentally realized materials. Extensions to new situations involving purely spin models are also mentioned.

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