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Vortex-line condensation in three dimensions: A physical mechanism of bosonic topological insulators[1] PENG YE, ZHENG-CHENG GU, Perimeter Inst for Theo Phys — 3d bosonic topological insulators (BTI) are symmetry protected topological(SPT) phases with U(1) and Z_2^T (time-reversal symmetry with T^2=1). BTI were first proposed based on the group cohomology theory which suggests two distinct root states. Soon after, surface anomalous topological orders were proposed to identify different root phases and also leads to a new root state beyond group cohomology. Nevertheless, it is still unclear what is the universal physical mechanism for BTI phases. In this work, we answer the question by proposing an universal physical mechanism via vortex-line condensation in a superfluid, e.g., helium-4 or cold atoms in optical lattices. Using such a simple physical picture, we find three root phases, of which two of them are classified by group cohomology theory while the other is beyond group cohomology classification. The physical picture also leads to a "natural" bulk dynamic topological quantum field theory (TQFT) description for BTI and gives rise to a physical pathway of practical realization. Finally, we generalize the vortex-line condensation picture to other symmetries and find that in three dimensions, even for a unitary Z_2 symmetry, there is a nontrivial Z_2 SPT phase beyond the group cohomology classification.

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