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3D quantum liquid crystals by condensation of dislocation worldsheets ARON BEEKMAN, Keio University, KAI WU, Stanford University, JAAKKO NISSINEN, JAN ZAANEN, Leiden University — A solid can partially melt into a liquid crystal where rotational rigidity is maintained while translational symmetry is restored. The topological melting is caused by an unbinding of dislocations. We recently provided a comprehensive review of quantum dislocation-mediated melting in 2D (arXiv:1603.04254). Through a duality mapping, phonons turn into dual gauge fields mediating interactions between dislocations. Upon condensation of dislocations, the dual gauge fields undergo the Anderson–Higgs mechanism and become gapped, signaling the loss of shear rigidity. Here we extend this theory to three dimensions. Dislocations are now linelike objects, strings, tracing out worldsheets in spacetime, while the dual gauge-fields become two-form (Kalb–Ramond) fields. We obtain the Higgs phase of these two-form gauge fields. Translational symmetry can be restored in three, two or one directions leading to nematic, smectic or columnar quantum liquid crystals. We derive the spectrum of low-energy excitations and its linear response. Goldstone modes due to broken rotational symmetry as well as superconductivity emerge whenever translational symmetry is restored. The peculiar features of liquid-crystalline order can be probed by finite-momentum spectroscopy.

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