Are there Upper Bounds on the Superconducting Transition Temperature?

Understanding limits on the superconducting transition temperature Tc is a question of fundamental and practical importance. I will begin by describing developments in quantum materials and ultracold Fermi gases that challenge conventional ideas on what controls Tc. I will then describe recent progress [1,2] on upper bounds on the superfluid phase stiffness in terms of the optical spectral weight. This in turn leads to upper bounds on BKT Tc of 2D systems irrespective of pairing mechanism or strength. The Tc bound is particularly simple for parabolic dispersion in 2D: Tc cannot exceed one-eighth the Fermi temperature. This bound has recently been realized in gate-tuned Li:ZrNCl. I will next present results for arbitrary band structures and multi-band systems and discuss applications to monolayer FeSe/STO and magic-angle twisted bilayer graphene. I will then turn to the problem of flat bands in 2D where the optical spectral weight is induced by interactions. I will discuss bounds for both trivial and topological flat bands [2] that depend crucially on the quantum geometry of the Wannier functions. Finally, I will discuss the open question of deriving bounds on Tc in 3D.

[1] T. Hazra, N. Verma, M. Randeria, PRX 9, 031049 (2019)
[2] N. Verma, T. Hazra, M. Randeria, arXiv:2103.08540.