Turbulence in atomic superfluid gases

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In fluid, turbulence arises for high Reynolds number. An interesting situation arises when a fluid has zero viscosity, i.e., it becomes a superfluid, where the Reynolds number cannot be defined and furthermore, vorticity is restricted with quantized circulation. In a superfluid, a turbulent flow is formed with a complex tangle of many vortex lines, which is referred to as quantum turbulence (QT). QT has been studied for decades in superfluid helium, leading to an intriguing comparative study between QT and classical turbulence. In this talk, I will present our experimental study of QT with various atomic superfluid gases in highly oblate quasi-2D geometry, where we observed a regular-to-turbulent transition of vortex shedding pattern as in the classical fluids, the vortex-antivortex pairing in decaying 2D QT turbulence, and the spontaneous defect formation in the nonequilitbirum superfluid phase transition dynamics. I will also introduce our recent extension with spinor superfluid systems that has internal spin degree of freedoms allowing much richer superfluid dynamics including exotic topological objects such as half-quantum vortices and skyrmions.