Hydrodynamics at the Largest Scales

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The general theme of these 3 lectures will be the coupling of microscales, mesoscales, and macroscales. I'll begin by establishing the broader context for the problem, and then illustrating it by:

(1) Developing a fluid theory for relativistic cosmic ray particles, which comprise about 10^{-9} – 10^{-10} of the particles in the diffuse gas that pervades galaxies but carry about as much energy as the thermal gas, and
(2) Developing a theory for dissipating large scale turbulence, heating plasma, and creating a nonthermal "tail" of high energy particles in a weakly magnetized, low density medium in which particle-particle collisions are rare.
(3) Time permitting, we will discuss a third problem: the effective "equation of state" of interstellar gas in galaxies.

I'm aware that many (most?) of the students in this course have no background in either plasma physics, or astrophysics, so I'll do my best to present the content in a way that emphasizes the universals. Unfortunately, the refereed literature doesn't always aspire to that. Some documents that may be helpful:

The Basis for Cosmic Ray Feedback (derivation of the fluid equations for a plasma physics readership)
Plasma Instabilities & Magnetic Field Growth in Clusters of Galaxies (early paper on collisionless turbulence in very hot, diffuse gases)

A set of slides I showed earlier this at the Crafoord Symposium in honor of Eugene Parker. They were intended for a multidisciplinary audience.

I'm also working on a pedagogical review of fluid theories for cosmic rays based on some lectures I gave earlier this summer and will share them when I have a complete draft.