# Final Thoughts

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An old astrophysical adage is: "If you don't understand it, invoke magnetic fields." Well, now you can!

# Materials Covered

- Basic Plasma Physics Theory
  - Charged particle motion
  - Magnetohydrodynamics (waves, shocks, instabilities)
  - Collisionless plasmas (waves, Landau damping, quasi-linear theory)
  - Coulomb collisions, transport coefficients, and fluid closure
  - Turbulence, reconnection, and dynamo
  - Partially ionized plasmas
- Astrophysical Applications
  - Accretion disks and disk winds/jets
  - Shocks and cosmic-ray acceleration
  - Instabilities in dilute astrophysical plasmas (solar wind, galaxy clusters, accretion disks)
  - Stellar, galactic, and planetary magnetic fields
  - Space weather
- Computational Methods

# To understand astrophysical plasmas, we must connect to laboratory and heliospheric plasmas

- Astrophysical plasmas
  - Extreme regions of parameter space
  - Very limited observations of small-scale processes
- Solar atmosphere
  - Global consequences of small-scale plasma processes
  - Observations possible at very high spatial resolution
- Space plasmas
  - Direct investigation of collisionless plasma processes
  - *In situ* measurements for small-scale physics
- Laboratory experiments
  - Test models under controlled settings
  - Abundant diagnostics but relatively modest plasma parameters

# Plasma astrophysics is an important and emerging field

- Necessary to describe a variety of astrophysical phenomena
  - Stars, galaxies, planets, compact objects, diffuse media
- Plasma processes are often coupled to other plasma processes
  - Particle acceleration is coupled to shocks & instabilities
  - Dynamos are coupled to turbulence & reconnection
  - Turbulence is coupled to waves, reconnection, & headaches
- Astrophysical plasmas are host to rich and interesting physics

# Thoughts?

- Astronomy 253 is a relatively new course
  - Offered for the first time two years ago
  - Feedback will help improve the class for next time
- Suggestions? (course evaluations also available online)
  - Topics
  - Problem sets
  - Projects
  - Level of difficulty
  - Components of other classes that could be applied to this one