Study of Physics Issues Related to Astrophysics in NSTX

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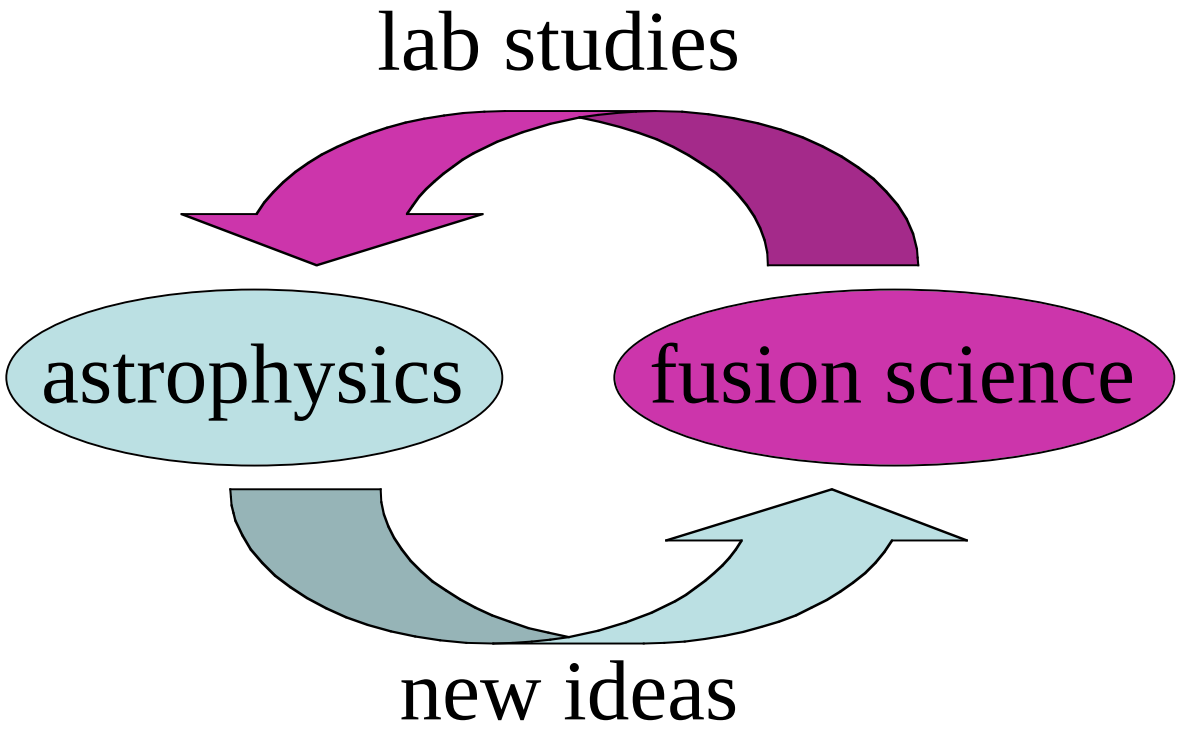
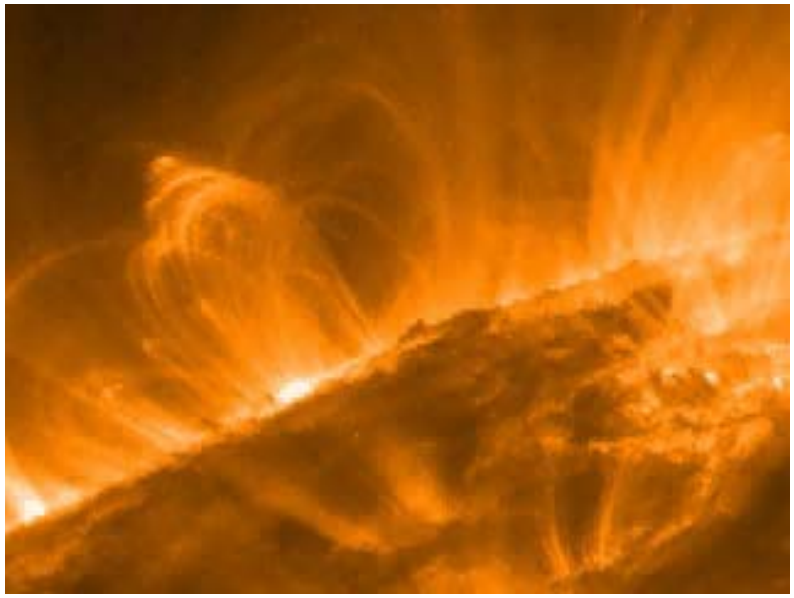
Why Plasma Astrophysics in NSTX?



- Physics-oriented research complements performance-oriented research
- Enhance impact of NSTX research on astrophysics
- May bring in new ideas and concepts as in the past

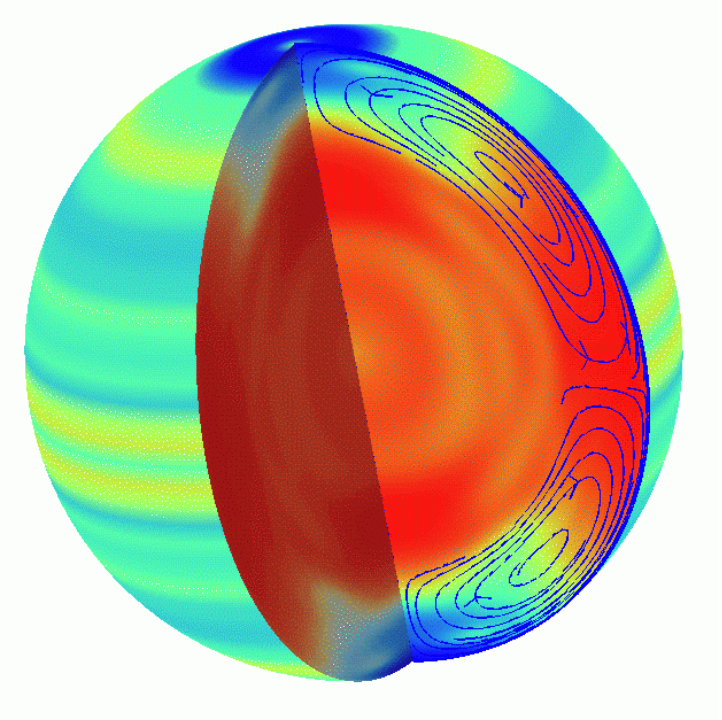
Example: Magnetic Reconnection



- **In Space and astrophysics:**
  - **Earth and planet magnetospheres**
  - **Coronal activities on star surfaces**
  - **Accretion disks**
- **In NSTX:**
  - **IRE (minor or major disruptions?)**
  - **CHI (current/helicity transport)**
- **Issues can be studied in NSTX**
  - **Kinetic effects (ρ_i dependence)**
  - **Effects of pressure gradient**
  - **2D versus 3D reconnection (in CHI and IRE)**
- **Needed resources**
  - **Internal magnetic diagnostics and imaging**
  - **Dedicated theory+simulation**
- **Impact on NSTX**
  - **Avoidance of IRE**
  - **Better understanding CHI and its applications**

Example: Angular Momentum Transport

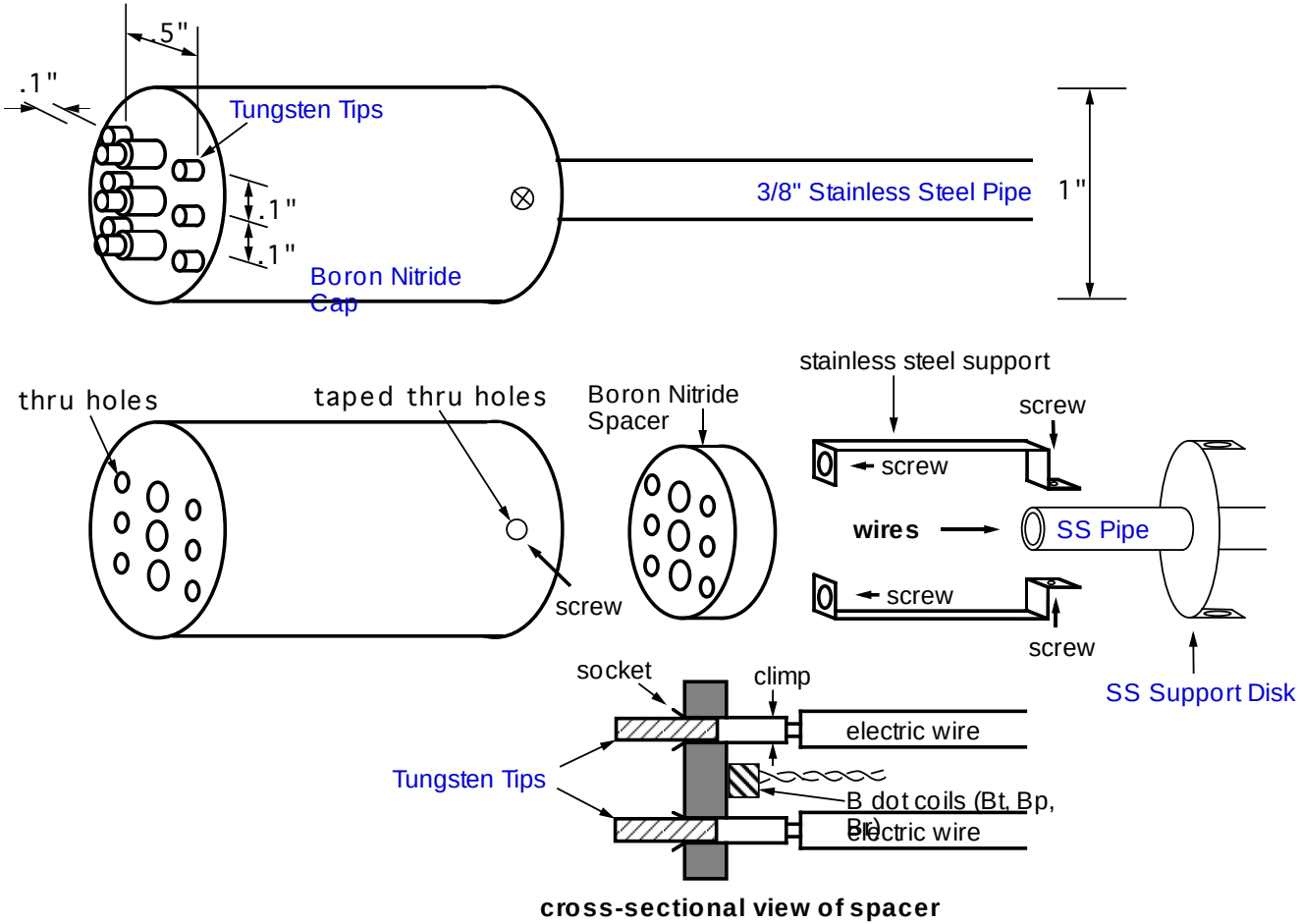
- **In Space and astrophysics:**
  - **Differential rotation in solar convection zone**
  - **Accretion disk**
- **In NSTX:**
  - **Measured significant toroidal flows**
- **Issues can be studied in NSTX**
  - **Reynolds stress versus magnetic Reynolds stress**
  - **Effects of low aspect ratios**
- **Needed resources**
  - **Diagnostics of flow and fluctuations**
  - **More momentum source (NBI) and its flexibilities**
  - **More theory+simulation**
- **Impact on NSTX**
  - **May be related to high ion temperatures**
  - **May be related to formation of diamagnetic cores**



Example: Dynamo Effect and Helicity Transport

- **In Space and astrophysics:**
  - **Origin of magnetic field**
  - **Self-organization nature of magnetic field (e.g. solar magnetic field)**
- **In NSTX:**
  - **CHI**
  - **IRE?**
- **Issues can be studied in NSTX**
  - **Mechanisms based on MHD or physics beyond MHD**
  - **Relations between dynamo effect and helicity conservation**
- **Needed resources**
  - **Fluctuation diagnostics at edge and core**
  - **Current drive capability and flexibilities**
  - **More theory+simulation**
- **Impact on NSTX**
  - **Better understanding and ideas for non-inductive startups**
  - **May lead to confinement improvement during CHI**

Dynamo Effect and Helicity Transport:
A Proposed Probe Head



In collaboration with UCSD (J. Boedo and G. Tynan)

Probe to Measure Many Important Effects due to Magnetic Fluctuations

- **The terms responsible for dynamo effects are**

$$\frac{\left\langle \tilde{E}_\theta \tilde{B}_\theta \right\rangle}{B_0} + \frac{\left\langle \tilde{E}_r \tilde{B}_r \right\rangle}{B_0} + \frac{\left\langle \tilde{B}_\theta \nabla_\theta \tilde{p}_e \right\rangle}{en} + \frac{\left\langle \tilde{B}_r \nabla_r \tilde{p}_e \right\rangle}{en}$$

MHD dynamo *diamagnetic dynamo*

- **In addition, the probe can measure toques due to fluctuations for studies of angular momentum transport**

$$T_{\theta r} = \frac{\left\langle \tilde{E}_\theta \tilde{E}_r \right\rangle}{B_0^2} - \frac{\left\langle \tilde{B}_\theta \tilde{B}_r \right\rangle}{\mu_0 m_i n}$$

Reynolds stress *magnetic Reynolds stress*

Summary

- More physics-oriented milestones in next 5 years
  - e.g. understand IRE in 5 years?
- Many physics issues related to astrophysics can be studied in NSTX
- Understanding these issues can help NSTX
- Need dedicated efforts and resources to make real progress and establish effective collaborations
  - e.g. joint research projects and programs
  - setup a small budget (e.g. $200k) each year as a seed money to foster new physics ideas (e.g. $50k/idea) through peer-reviewed competitions of 1-2 page proposals (w/ G. Tynan)