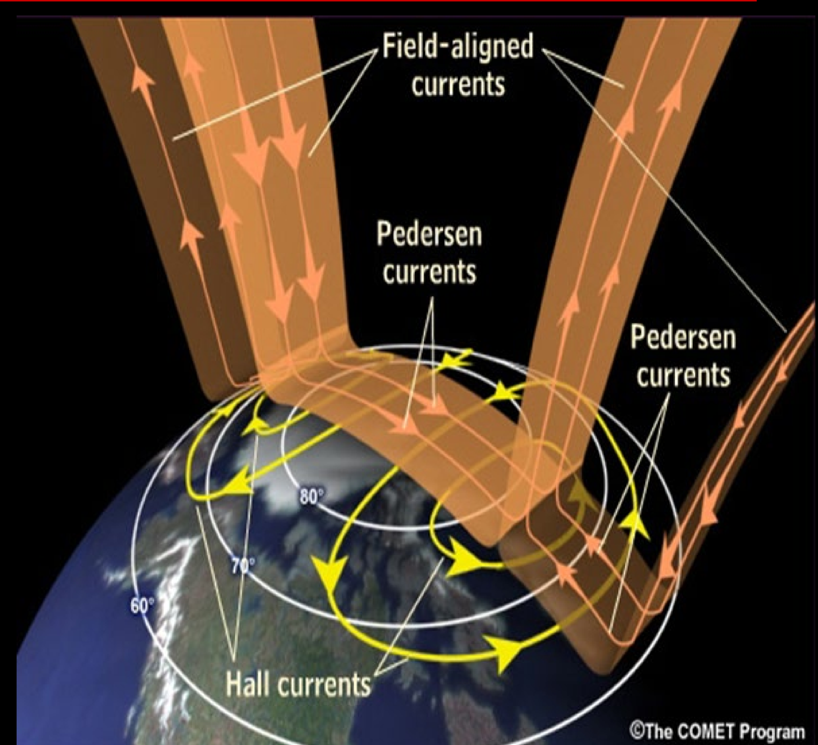
MITC-7, Wednesday, 24 June 2026: 15:30 - 18:30

Cross-Altitude Coupling of Electrojet Farley-Buneman Waves

Rattanakorn (Save) Koontaweepunya, Meers M. Oppenheim, Yakov S. Dimant, Samuel Evans

Boston University, Center for Space Physics, Astronomy Department

Farley-Buneman Instability (FBI)



- Intense electric fields during geomagnetic storms drive the Farley-Buneman instability (FBI) in the E-region ionosphere. The effect is most strong in the auroral electrojets during geomagnetic storms.
- The FBI can modify the conductivities and temperatures of the E-region electrojets.

EPPIC Simulations

- We performed 3D plasma simulations using EPPIC — the electrostatic parallel particle-in-cell simulator. The simulation parameters are typical of high-latitude E-region electrojets during geomagnetic storms.
- We compare 1 global simulation that spans the entire E-region with 8 simulations localized to specific altitudes. The global simulation is discussed in detail in Oppenheim et al. (2026).

Ion Density Perturbations

- Figure 1 shows a vertical slice of the global simulation. The ion number density is taken at the end of the simulation. The right axis shows the corresponding altitude in the high-latitude atmosphere.
- Figure 2 compares horizontal slices of the global simulation with corresponding slices from the local simulations.
- Figure 3 compares the energy spectra taken from the ion density waves at the end of the simulation. The spectra is plotted in k-space: k_H (Hall) vs k_P (Pedersen). The red x's mark the brightest spots.

Figure 1

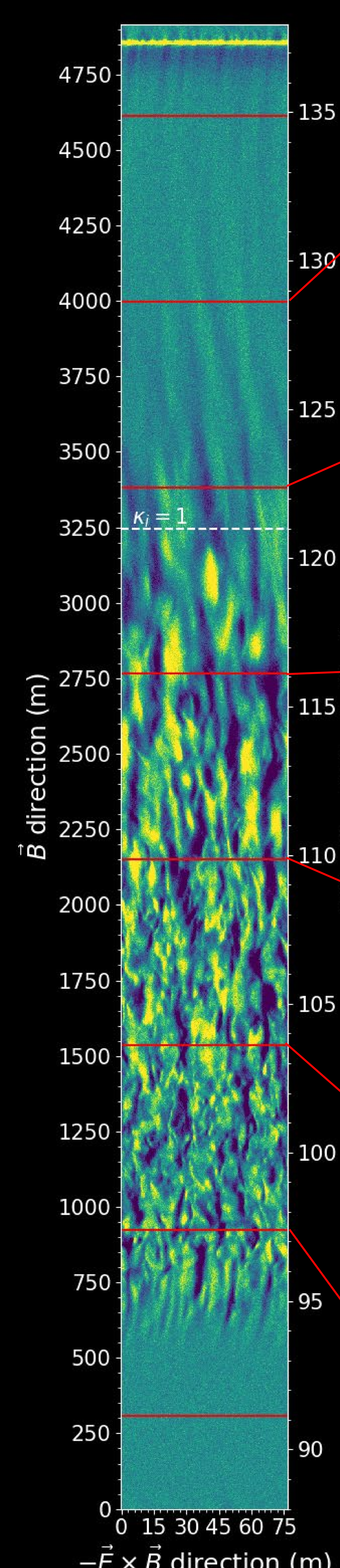


Figure 2

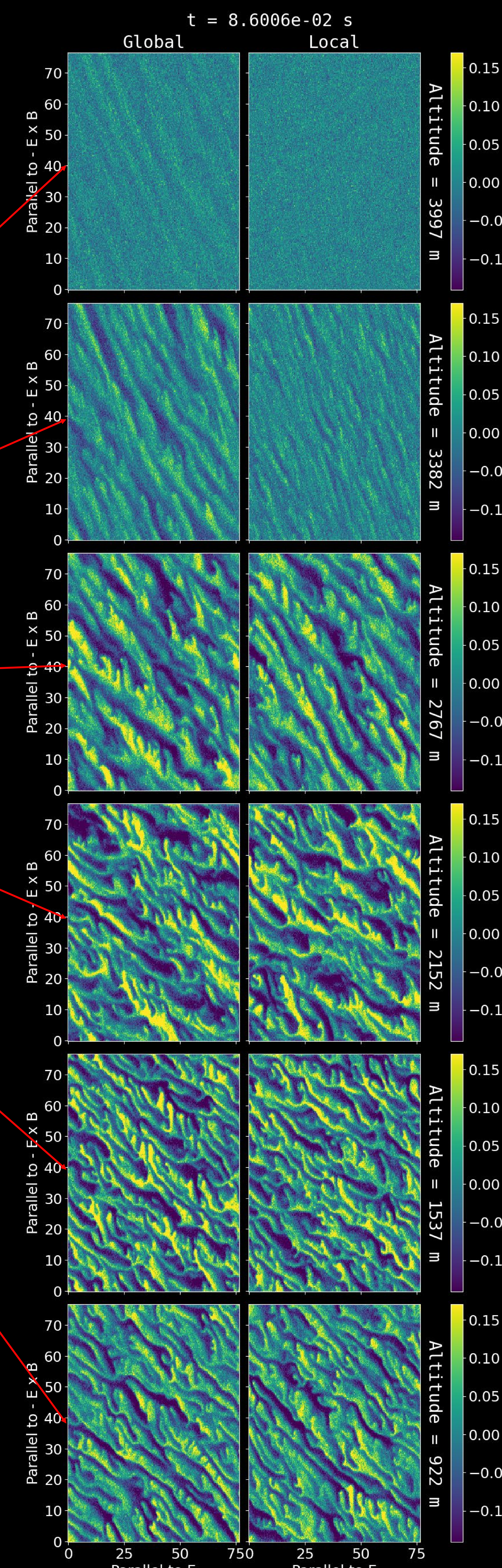
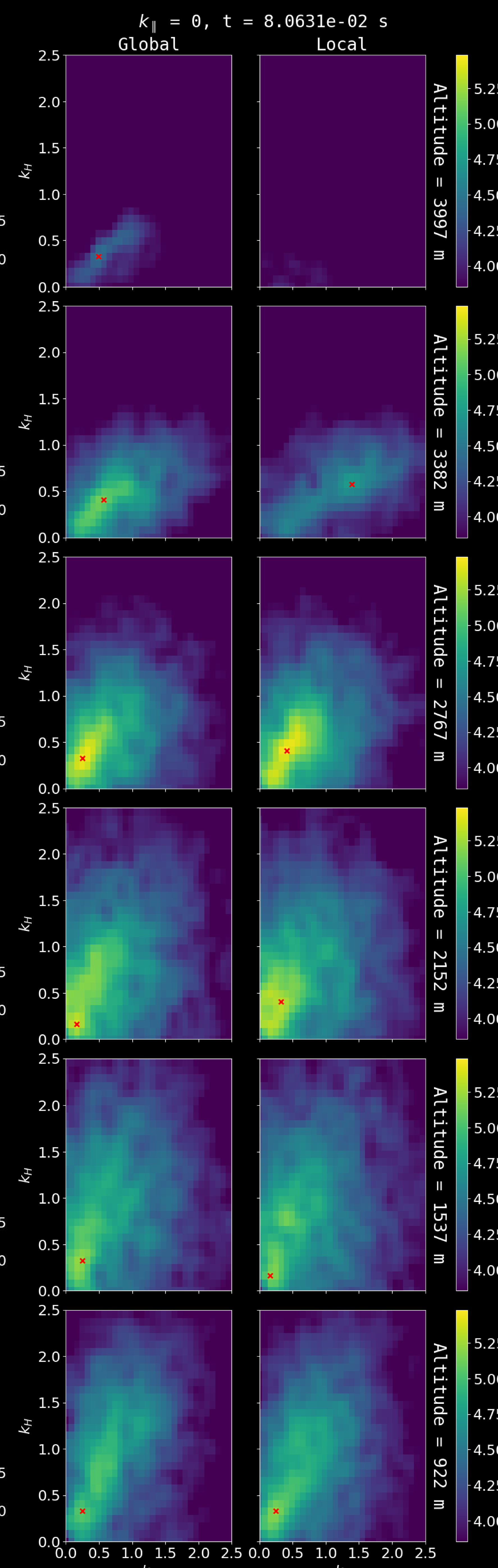


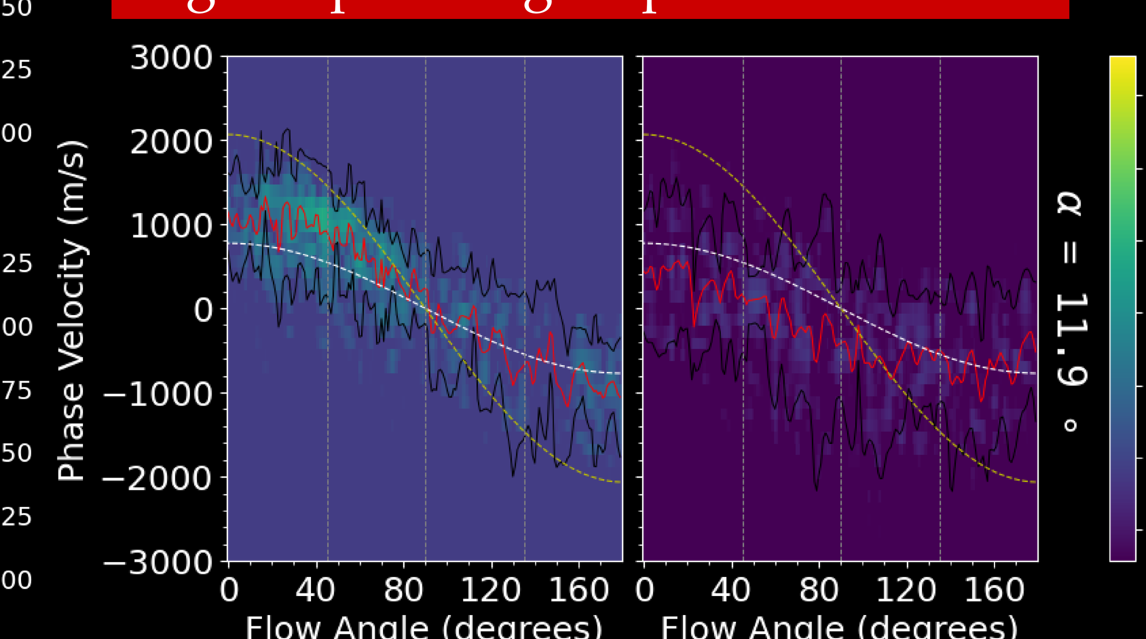
Figure 3



Cross-Altitude Coupling

- At altitudes above the ion magnetization boundary ($\nu_i = \Omega_i$; 3247 m), the global simulation shows stronger wave growths than the localized simulations.
- At 3382 m, the global simulation shows longer wavelengths (~9 m) compared to the localized simulation (~4 m). The flow angle is also less oblique (~60°) compared to the localized simulation (~70°).
- These characteristics are reminiscent of the lower altitude (i.e., 2767 m) where the wavelength is longer, and the flow angle is less oblique.
- Additionally, the global simulation shows wave development at 3997 m which is completely absent in the localized simulation. This is above the threshold altitude predicted in Dimant & Oppenheim (2004).

High Aspect Angle Spectra at 2767 m



- The plot shows energy spectra at an effective aspect angle of ~2° at an effective altitude of ~ 116 km.
- There is a strong signal in the global simulation but not in the localized simulation, suggesting that the waves in the global simulation has a large component parallel to the magnetic field.
- This can cause the waves to couple with the altitude above.

Reference

Dimant, Y., & Oppenheim, M. (2004). Ion thermal effects on E-region instabilities: linear theory.

Oppenheim, M. et al. (2026, accepted). First Kinetic 3-D Simulations of the High-Latitude Electrojet Spanning an Entire Turbulent Flux Tube

Contact: rakoon@bu.edu