

**Ion Thermalization and Wave
Excitation downstream of Earth's
Bow Shock: Cluster Observations of
 He^{2+} Acceleration and Theory**

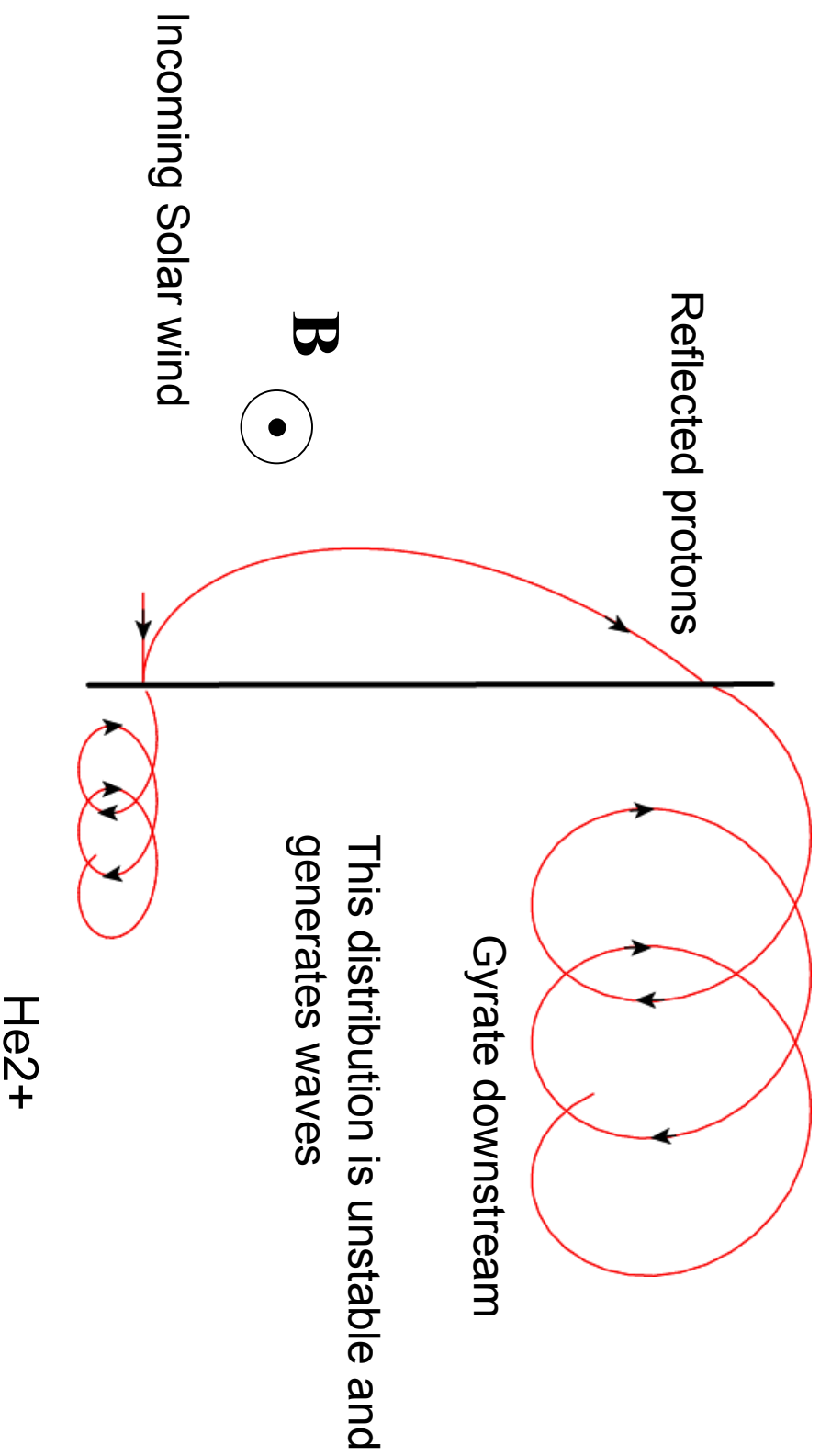
**Yong C.-M. Liu, Martin A. Lee,
Kucharek Harald and Bin Miao**

AGU 2006 FALL MEETING

Outline

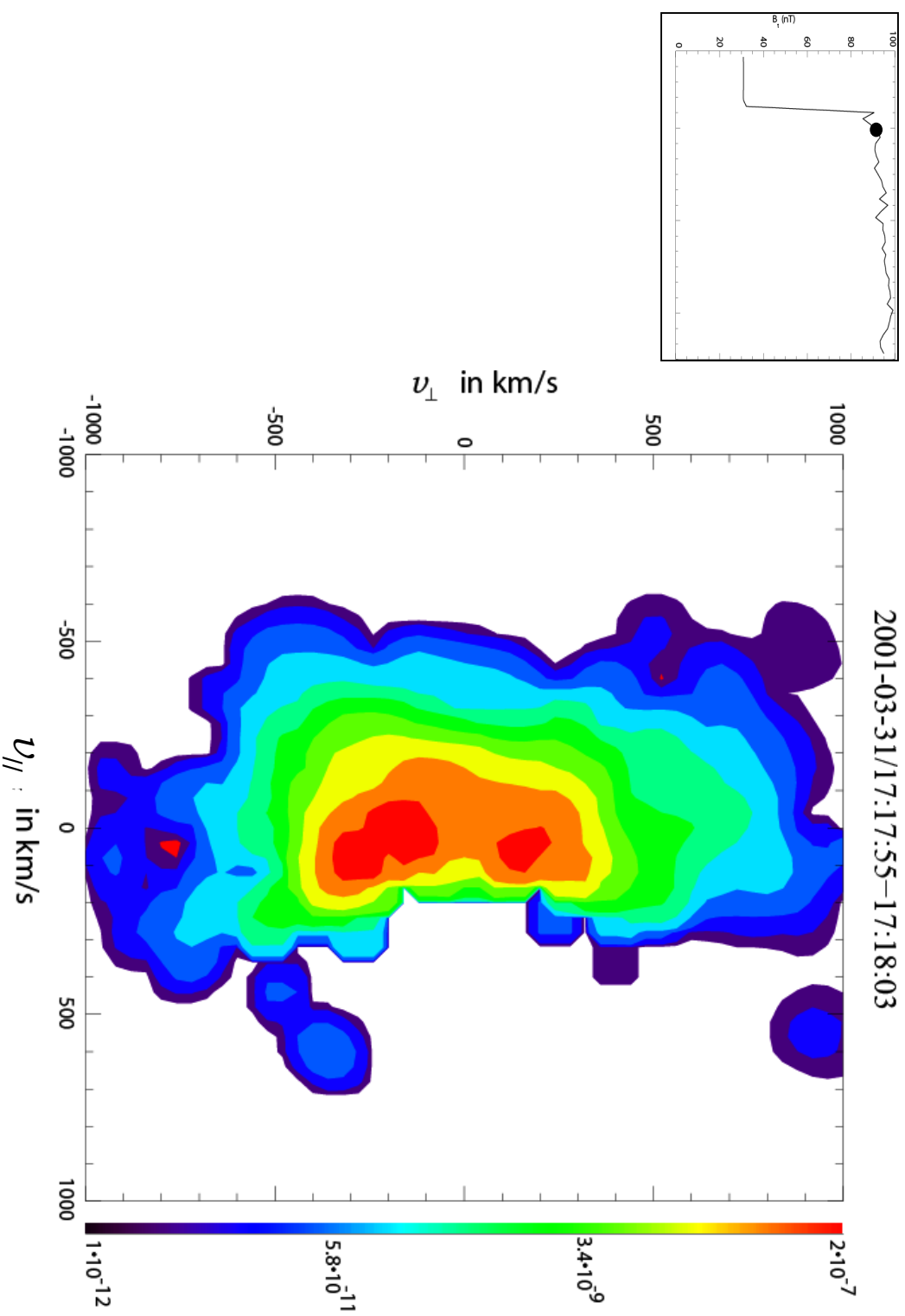
- **Observations** of Helium ions and waves downstream
distribution function, temperature and temperature anisotropy
- A quasilinear **theory** to predict the evolution of the temperature anisotropy and wave spectrum downstream

Shock and particles downstream

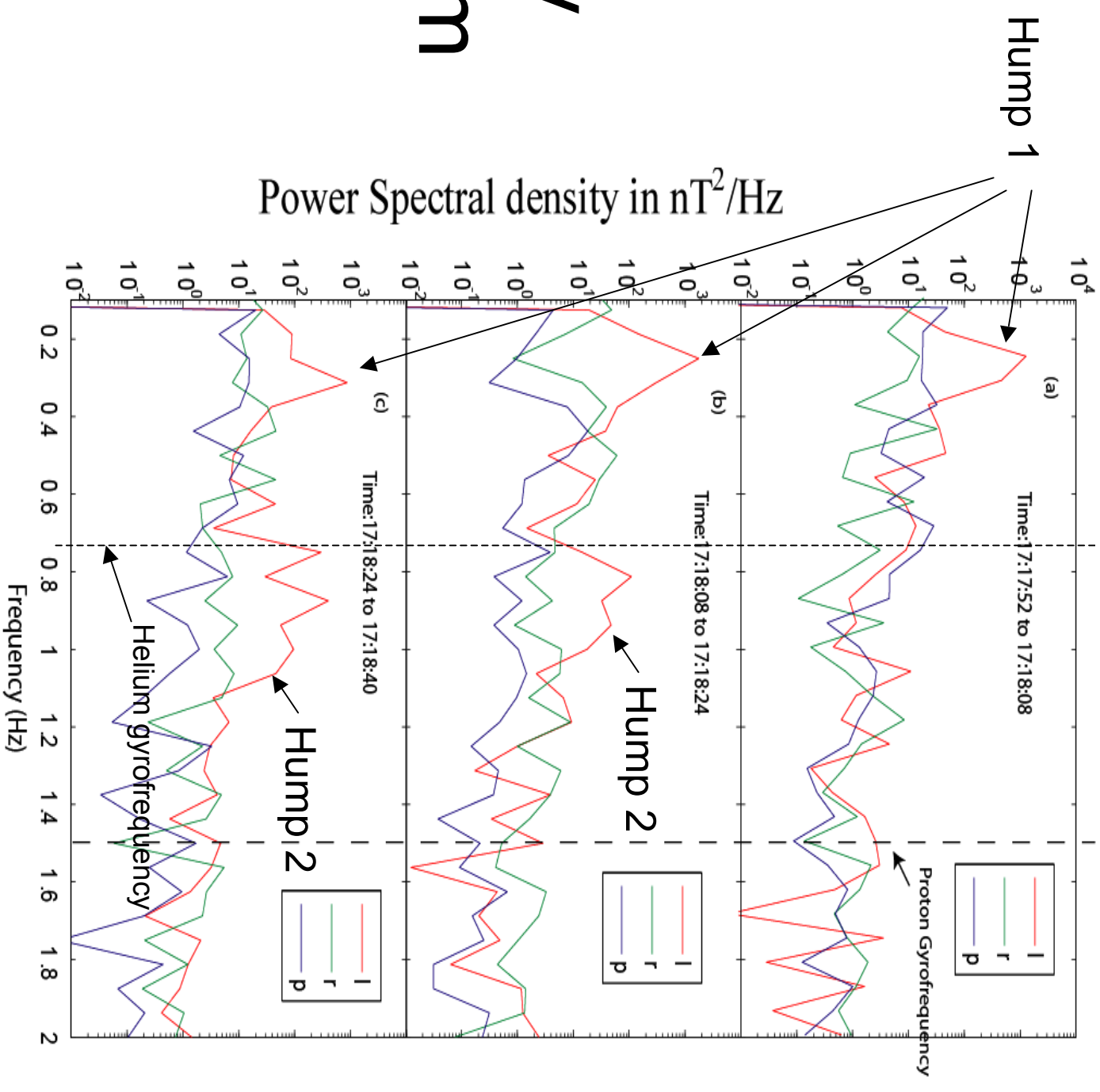


Liu et al., [2005]

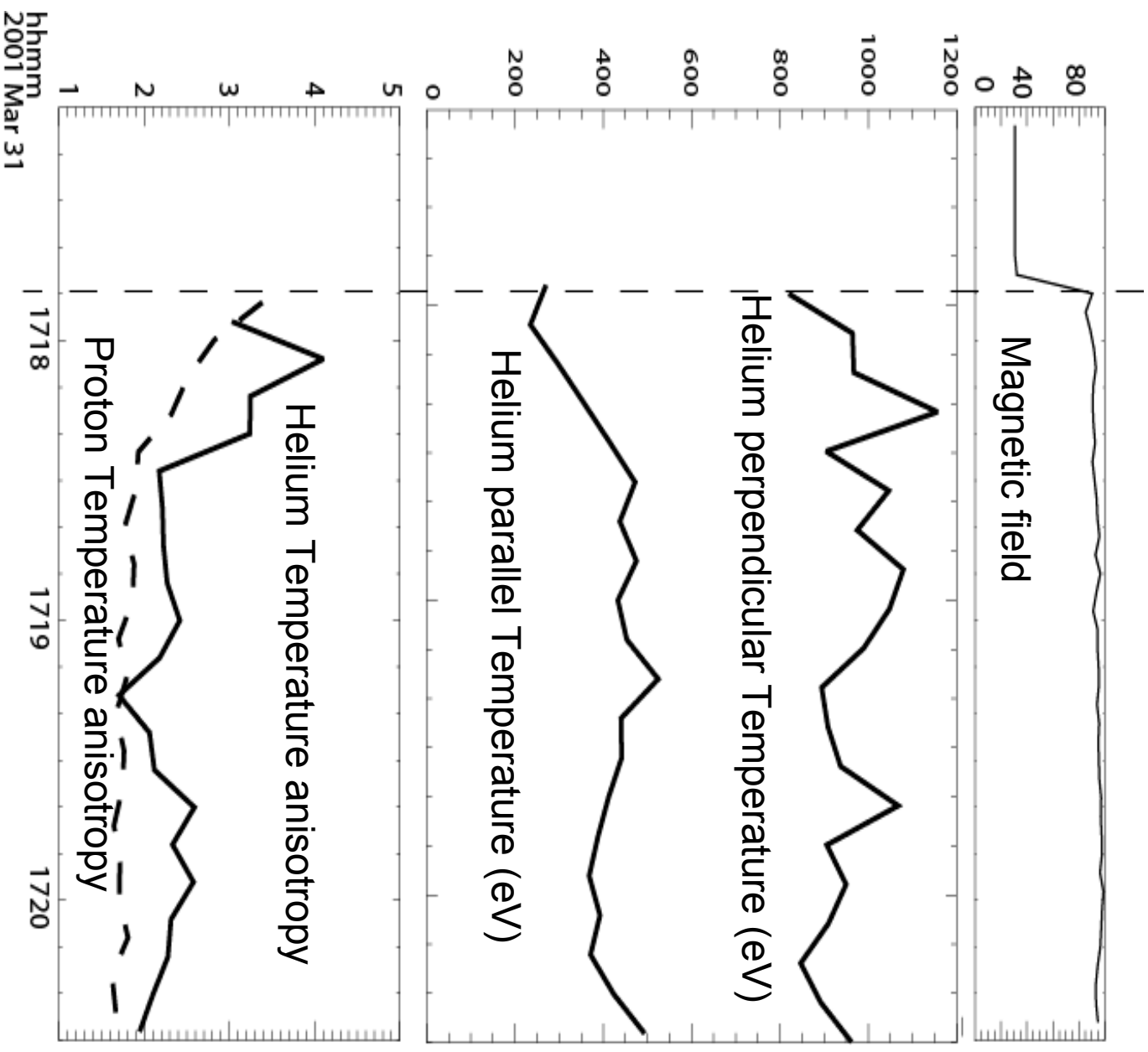
Cluster data 2- Ion distribution function just downstream



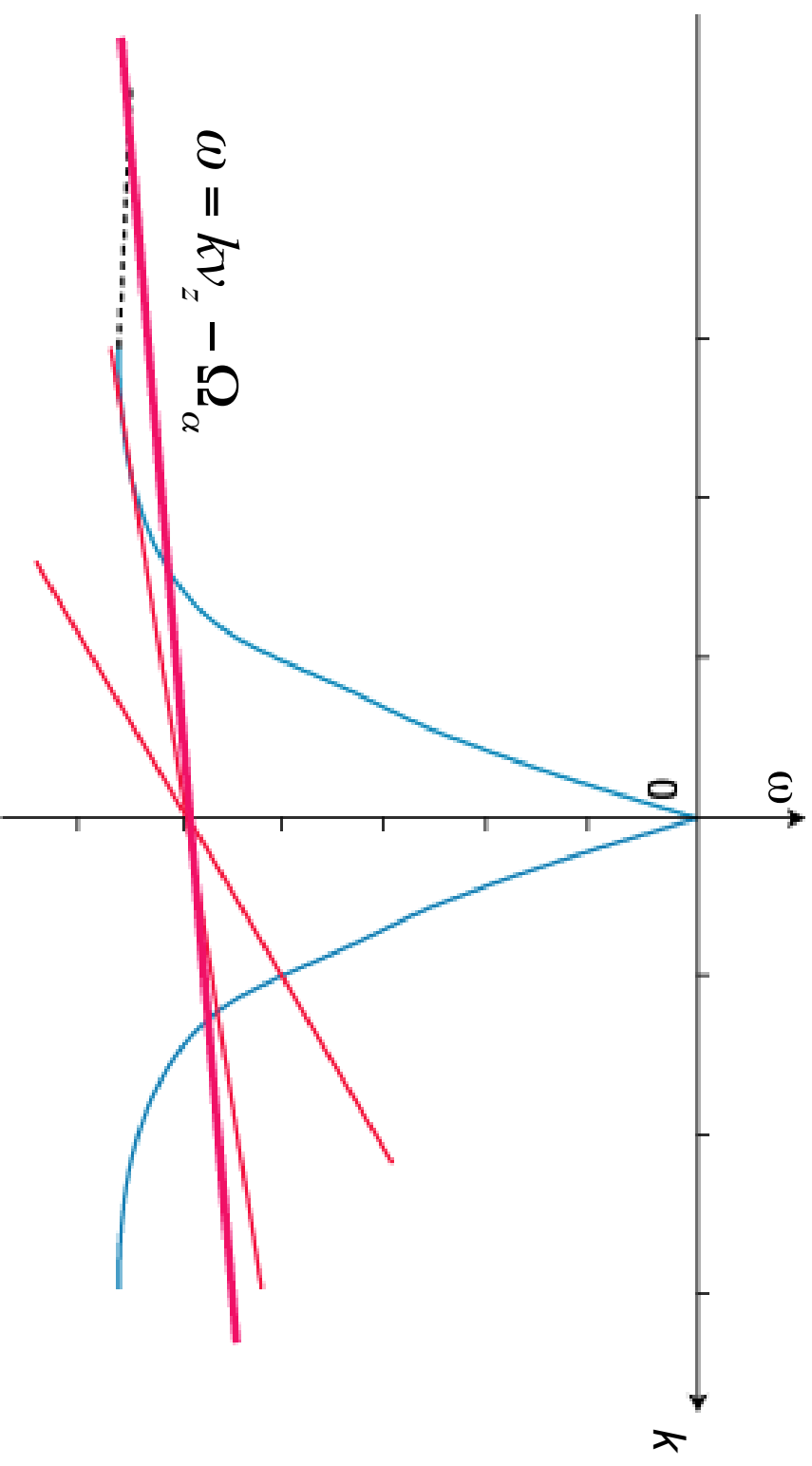
Power Density Spectrum



Cluster data: Temperature and Temperature Anisotropy

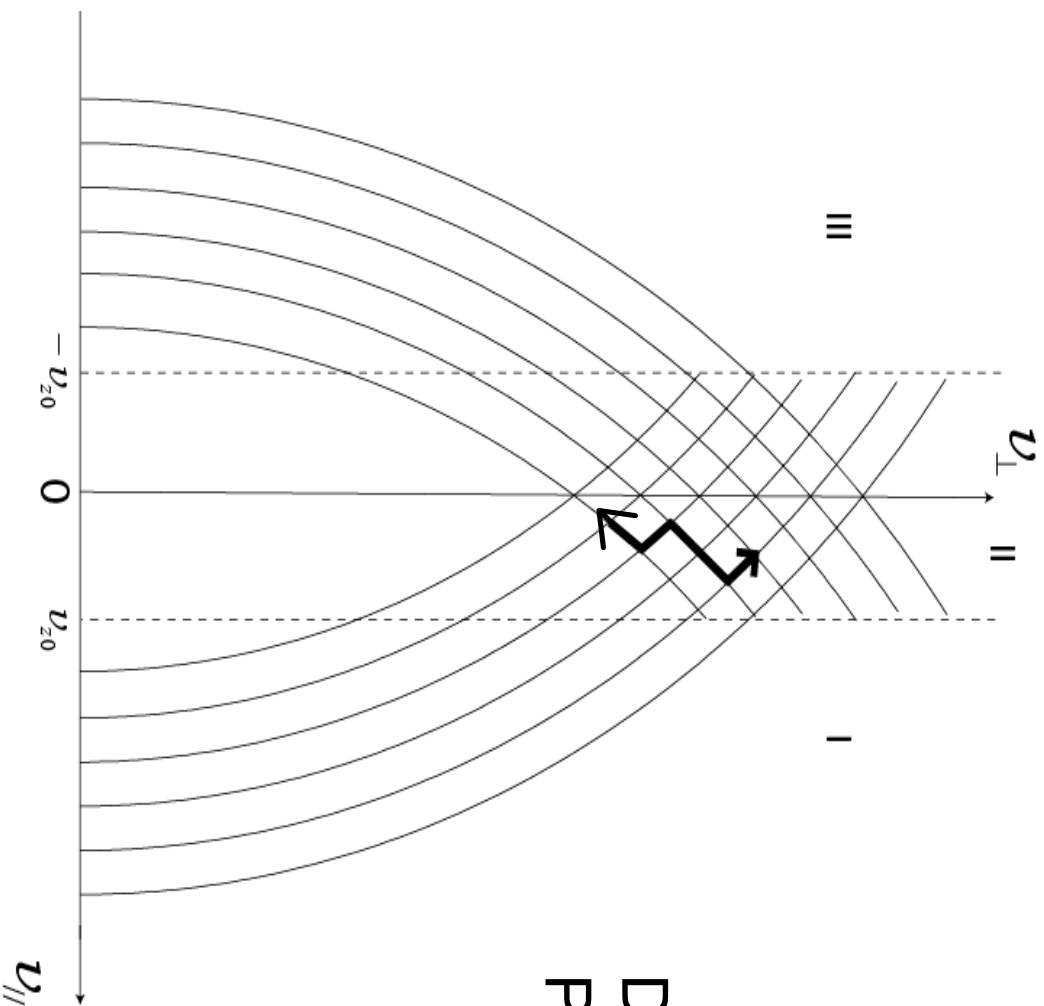


Double Resonances



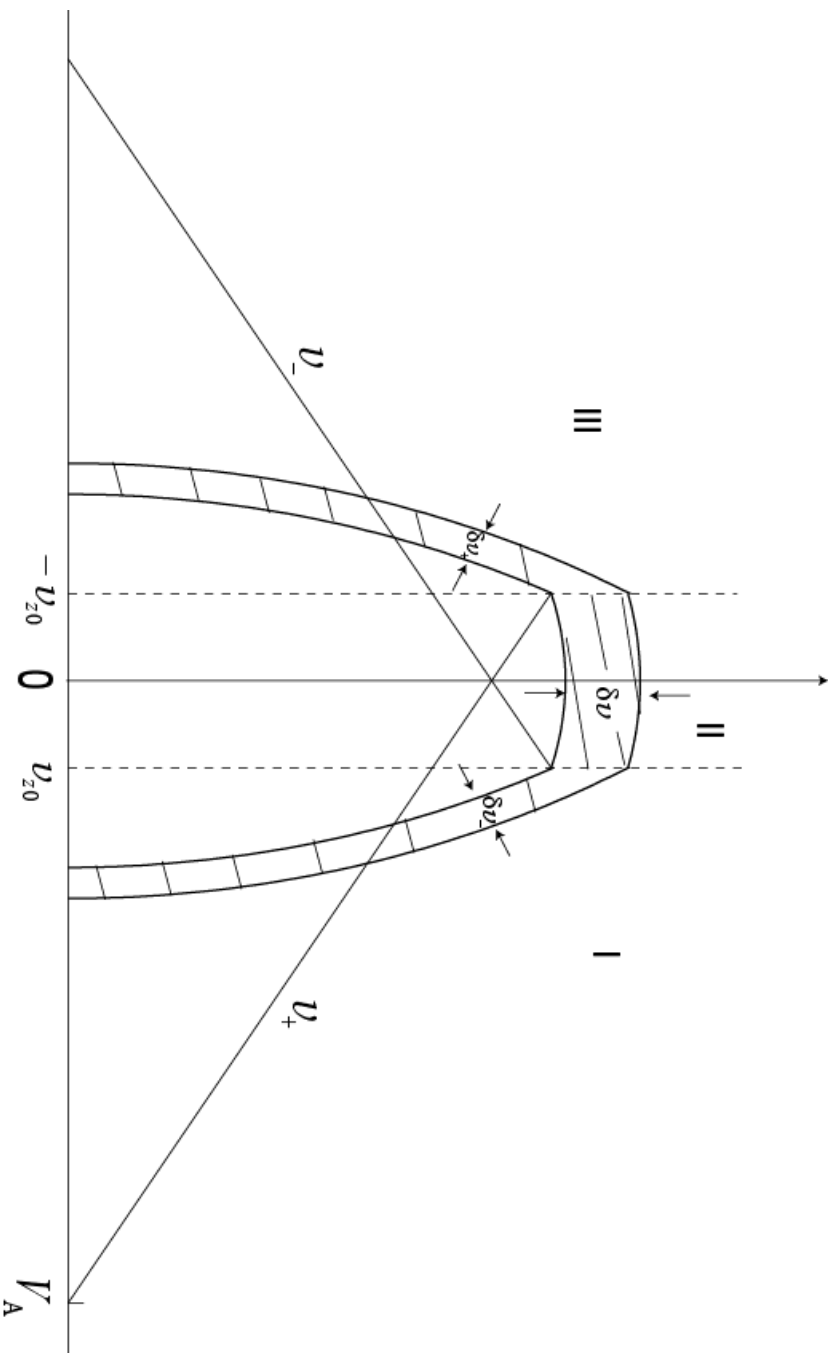
The thick **Pink line** has **three** intersections with the **blues line**

Stochastic Acceleration



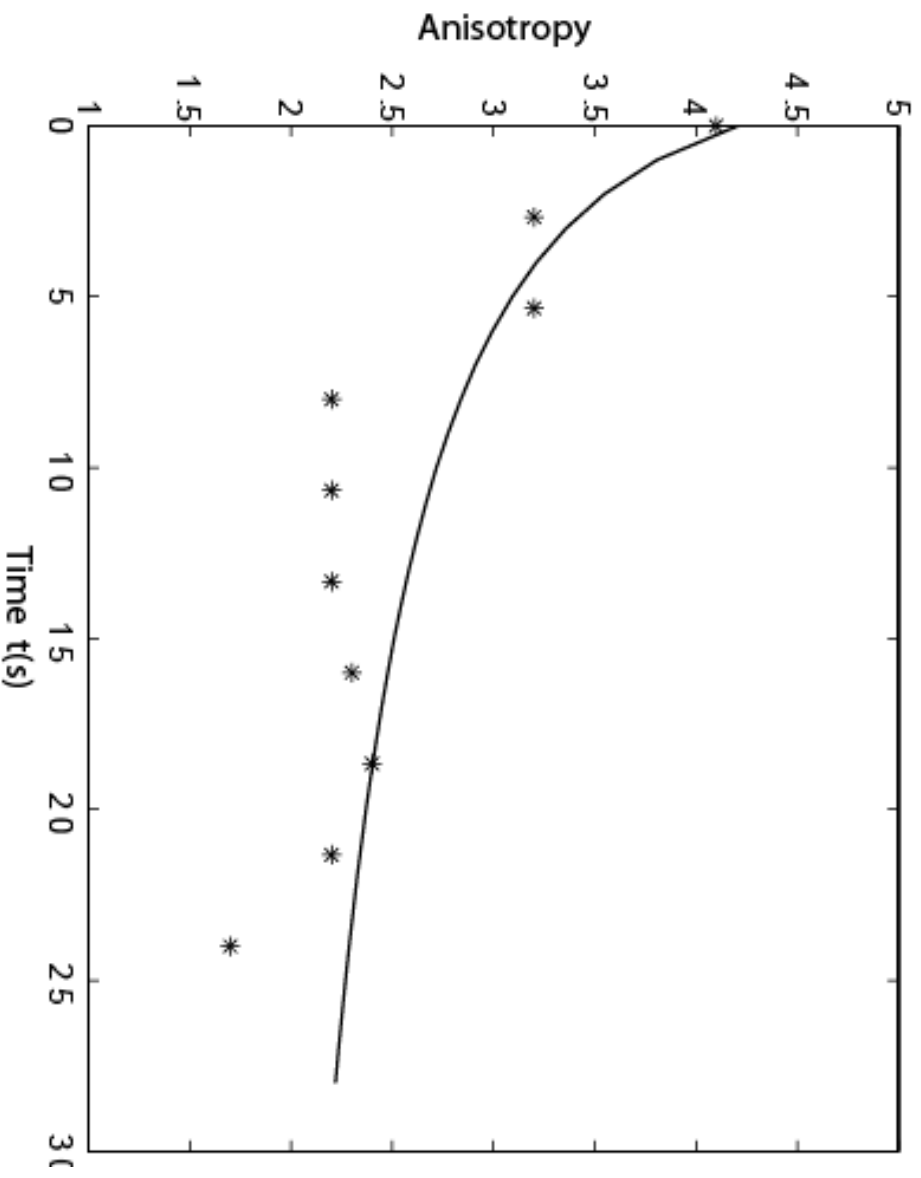
Double resonance leads to
Perpendicular diffusion

$$\frac{\partial F}{\partial t} = 2CV_p \frac{v_{z0} I}{\sqrt{v^2 + V_p^2} - V_p} \frac{\partial}{\partial v} \left(v \frac{\partial F}{\partial v} \right)$$



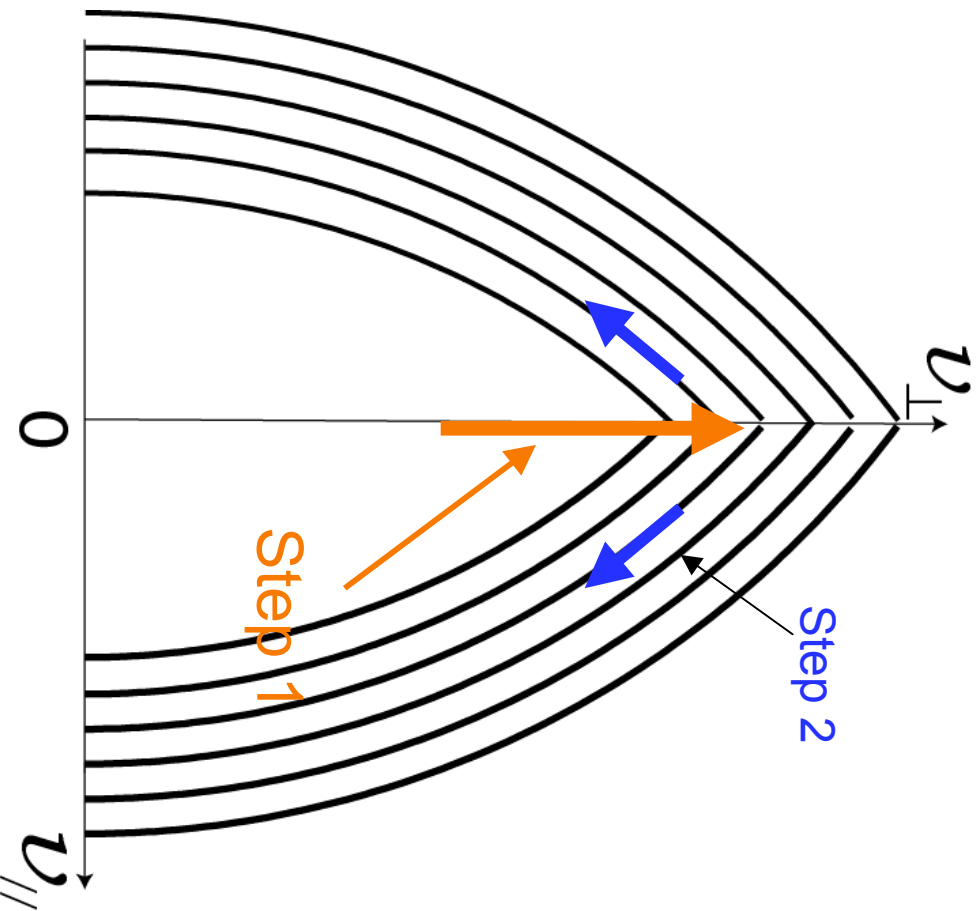
Under the assumption that the double resonance range is small compare with V_A ,

Predicted and Observed Temperature Anisotropy



Comparison of predicted (solid) and observed (*) helium temperature anisotropy

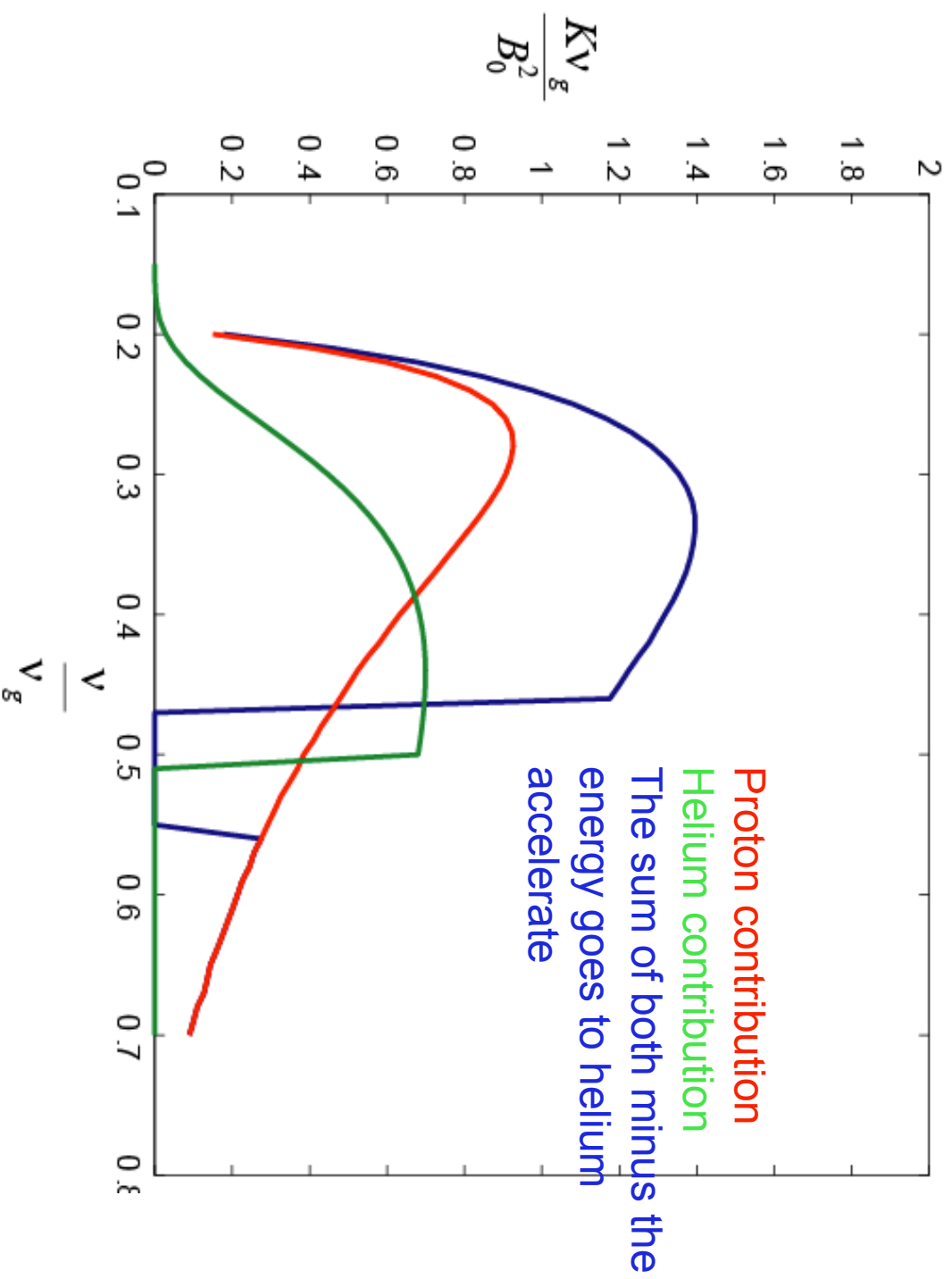
Ion Scattering and Wave Spectrum Calculation



Step 1: Helium ions are scattered to higher v_{\perp} and gain energy from waves

Step 2: Helium ions are scattered along the shells to larger v_{\parallel} and lose energy to the waves

Predicted Wave Spectrum



Conclusion and Discussion

- We predicted the Helium temperature anisotropy and wave spectrum downstream of Earth's bow shock. The predictions match the observations well.
- Quasilinear theory works remarkably well for lower-Mach-Number shocks
- Multiple spacecrafts mission is a powerful tool to investigate space physics processes
- The interaction of helium ions and waves just downstream of the Earth's bow shock needs further work