Elemental abundances, kinetic temperatures, and outflow speeds in coronal streamers

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THIS TALK:

- Above 1.4 $R_\odot$
- Ion Drag, Gravitational Settling

URI FELDMAN'S TALK:

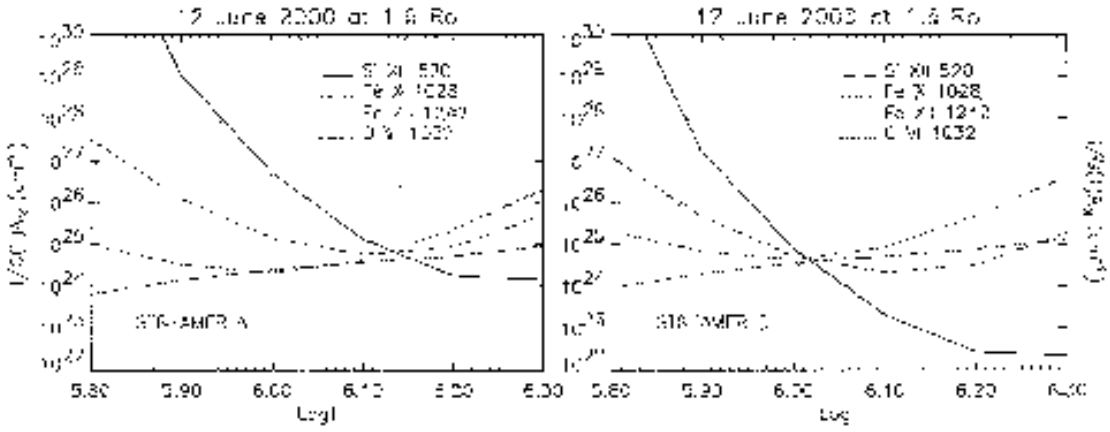
- Below 1.4 $R_\odot$
- FIP Effect

METHODS:

- White Light
  - pB $\rightarrow N_e$, morphology
  - Accelerating Blobs $\rightarrow$ V
- UV Spectra
  - Si, Fe ionization $\rightarrow T_e$
  - Thomson scattered Lyα $\rightarrow T_e$
  - Line widths $\rightarrow T_i$
  - O VI ratio, Doppler Dimming $\rightarrow$ V
  - Above + H I, O VI, Si, Fe lines $\rightarrow$ Absolute Abundances

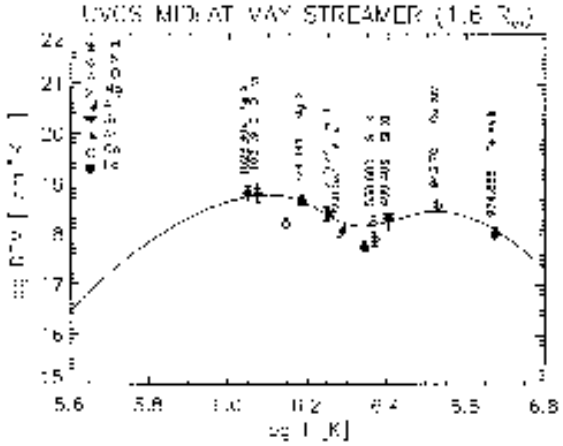
Electron Temperatures

Ionization Balance; Isothermal quiescent streamers



Bemporad et al. 2003

Multi-T above hotter active regions

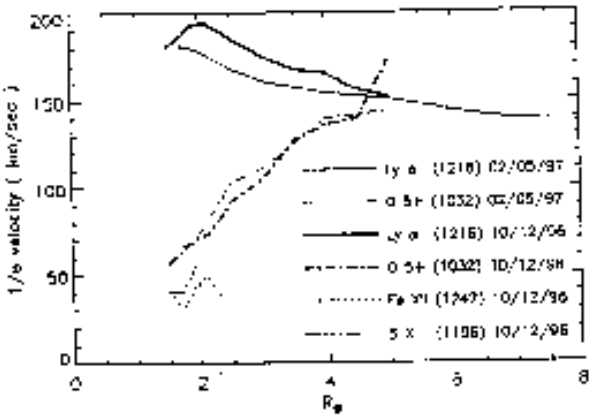


Parenti et al. 2000

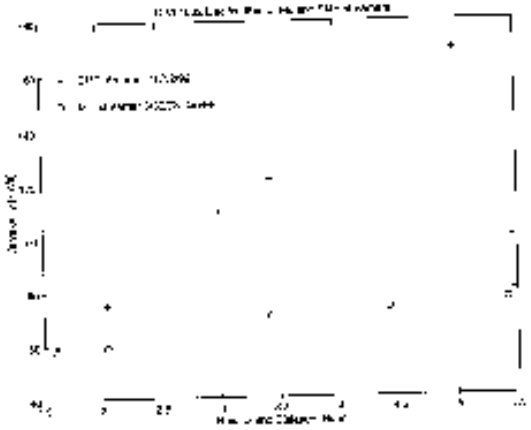
Thomson-scattered Lyα profile; Fineschi et al. 1998

Ion Temperatures

T_O varies with height and among streamers



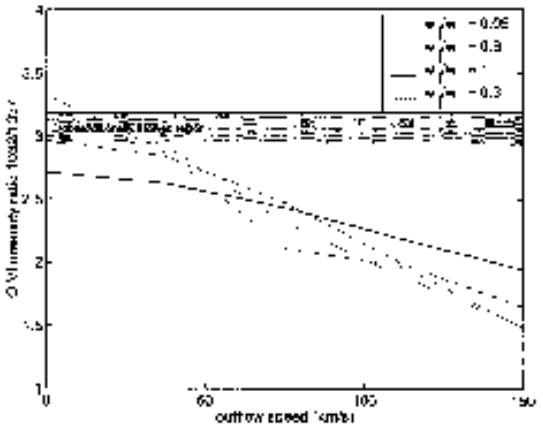
Kohl et al. 1997



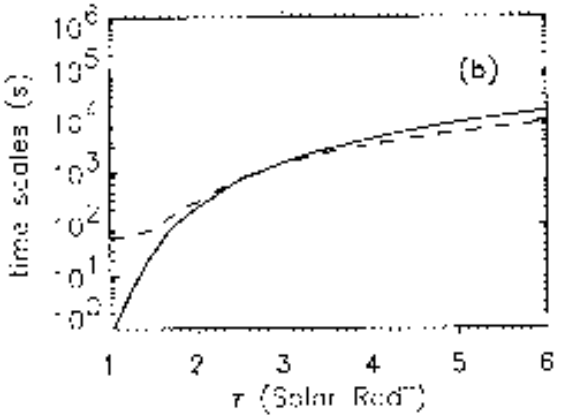
Frazin et al. 1999

Comparison of elements → non-thermal width ~ 20 km/s

Anisotropic distributions



Frazin, Cranmer & Kohl 2003

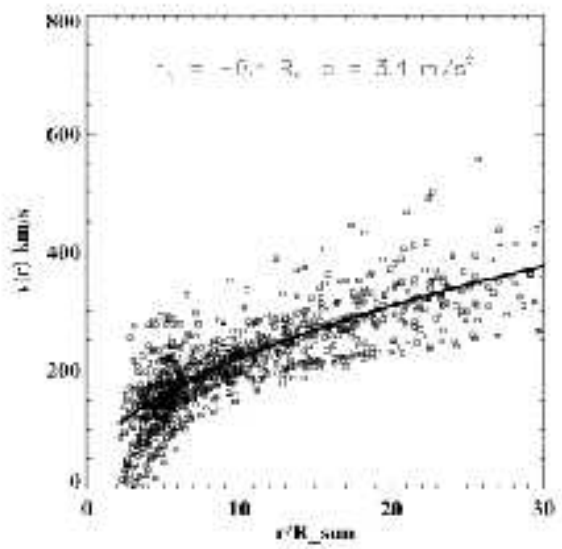


Chen et al. 2004

Density may control T_O

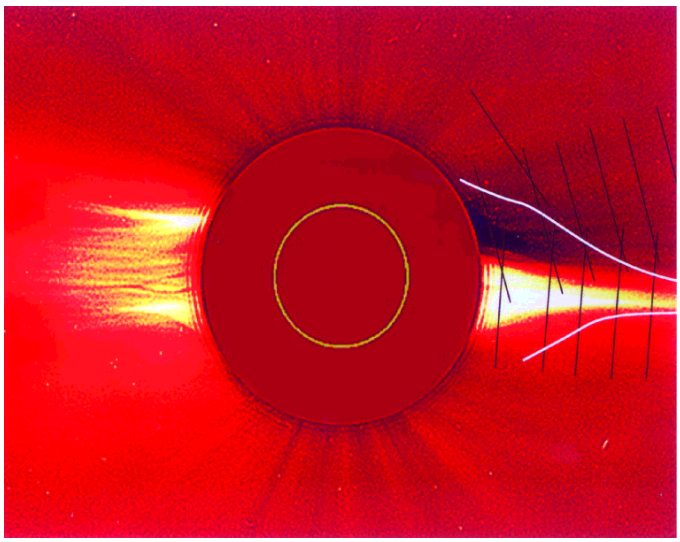
Velocities

Accelerating Density Enhancements above 2 $R_\odot$



Sheeley et al. 1997

Doppler Dimming and O VI-C II pumping



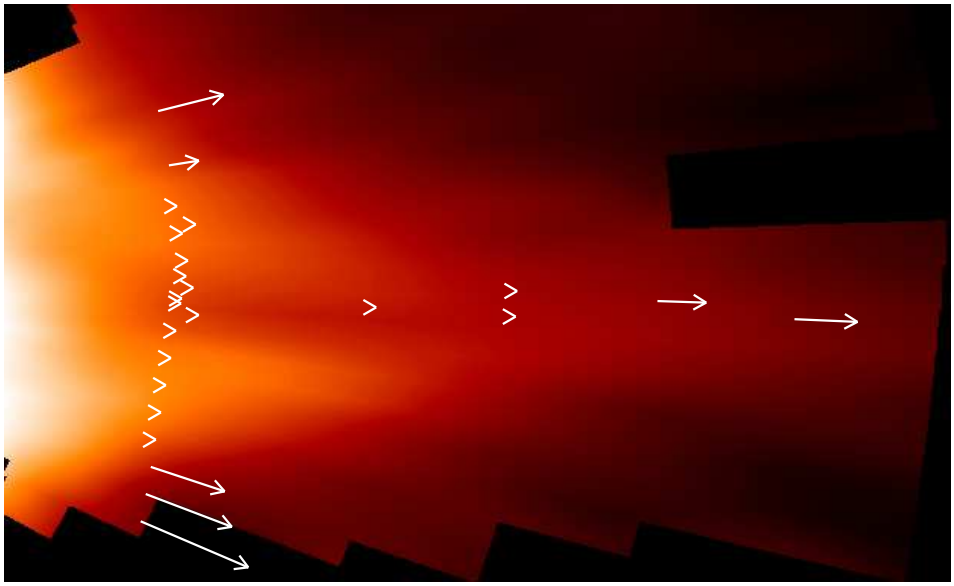
Habbal et al. 1997

O VI Doublet ratio determines V

V=100 km/s divides fast and slow winds

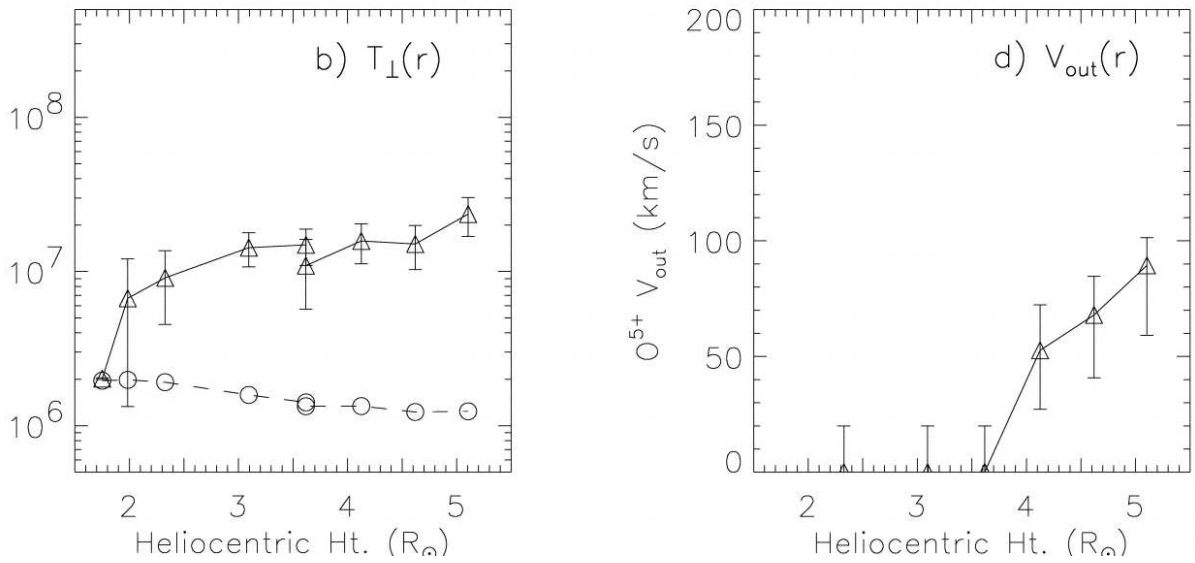
Velocities

O VI Velocities



Strachan et al.

Doppler Dimming Velocities from O VI

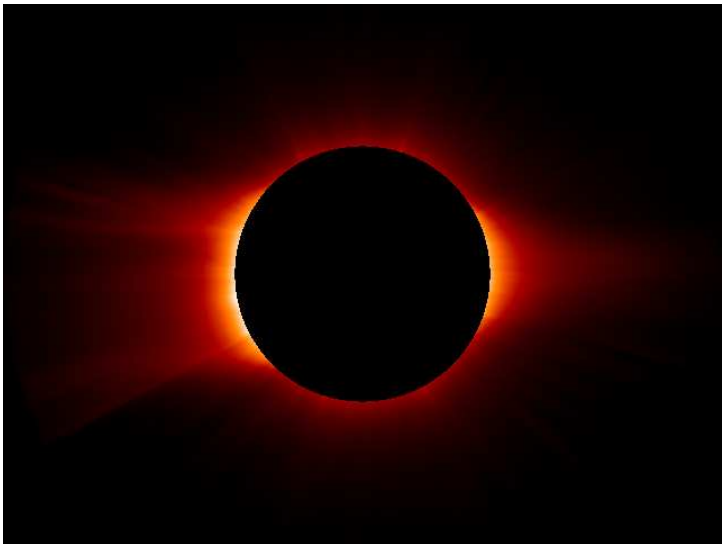


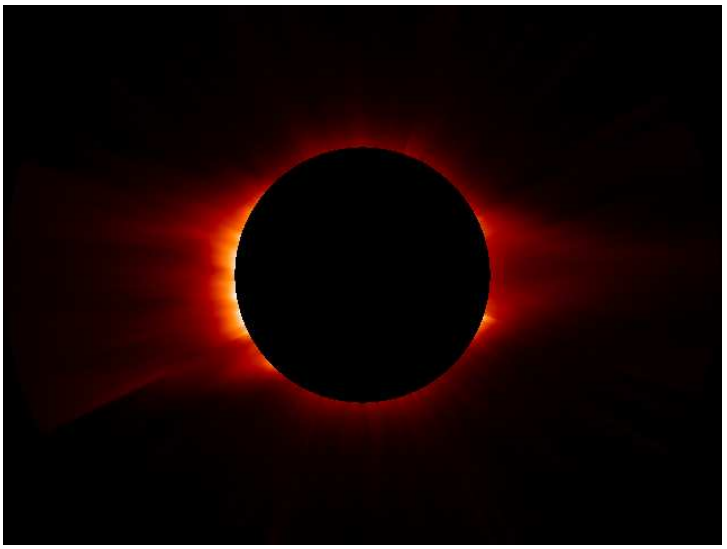
Strachan et al. 2002

V=0 on axis below 3 $R_\odot$

Absolute Abundances

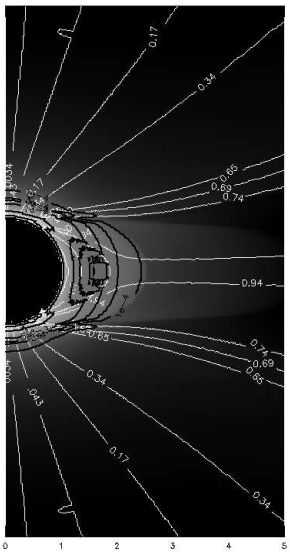
Lyα O VI

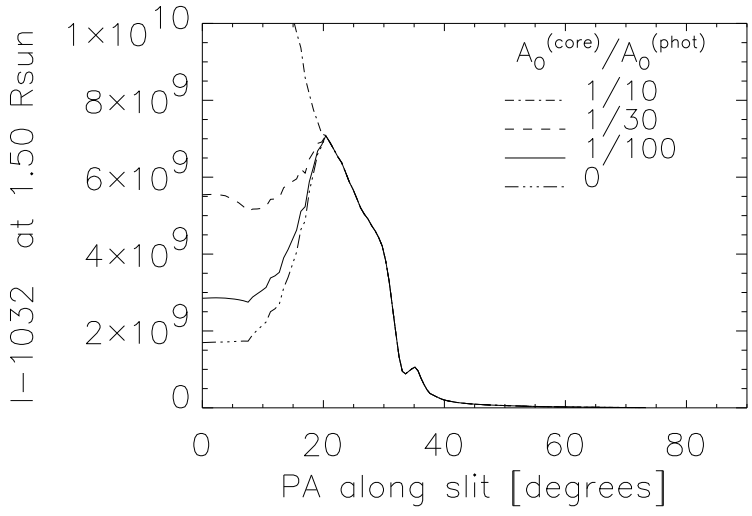




UVCS images Raymond et al. 1997

$[\mathrm{O/H}]_{core} = 1/3\ [\mathrm{O/H}]_{legs} = 1/10\ [\mathrm{O/H}]_{photosphere}$





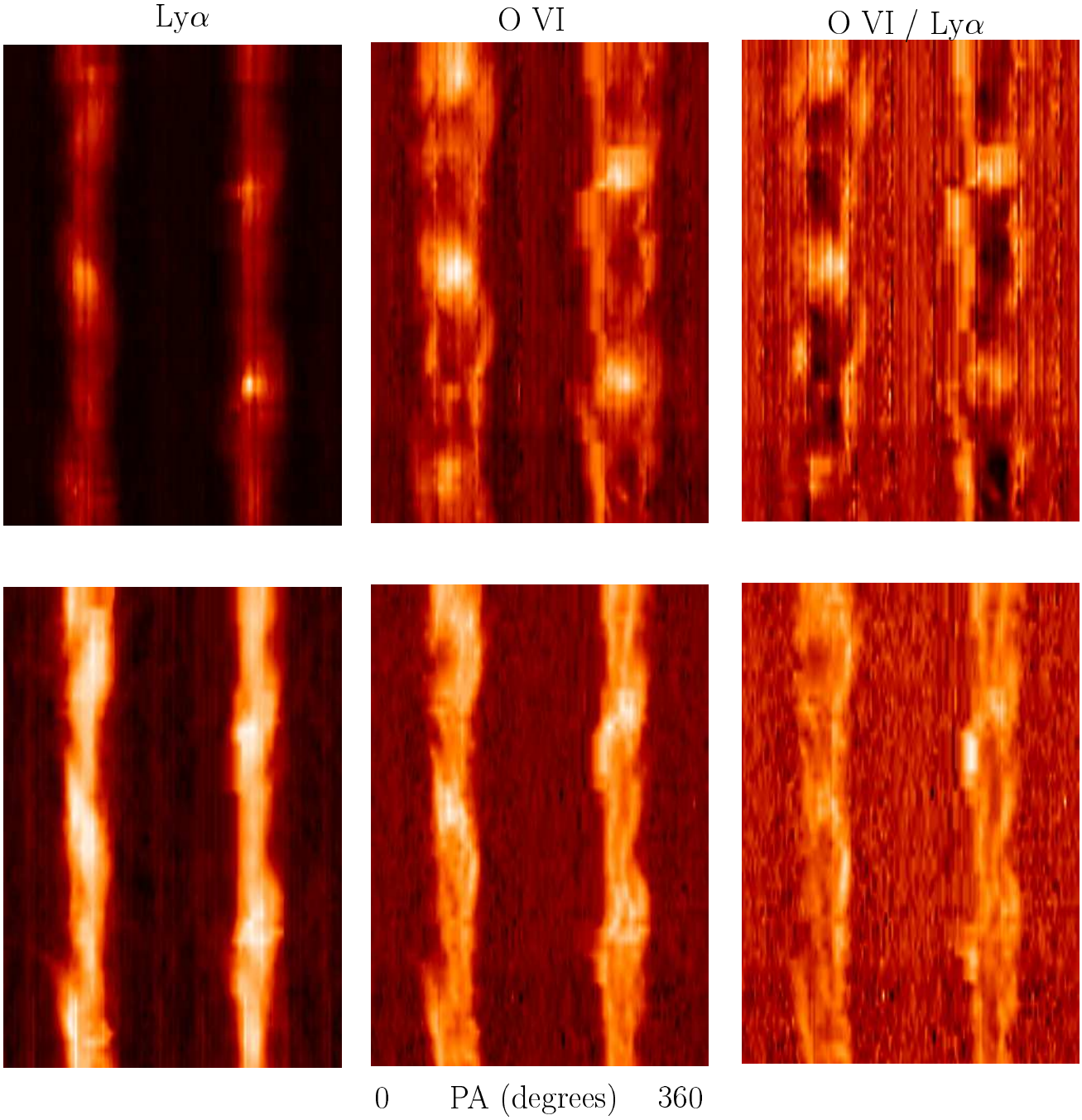
Vásquez & Raymond 2004

Projection Dominates O VI above 1.5 $R_\odot$

Carrington maps May 1-July 1 1996

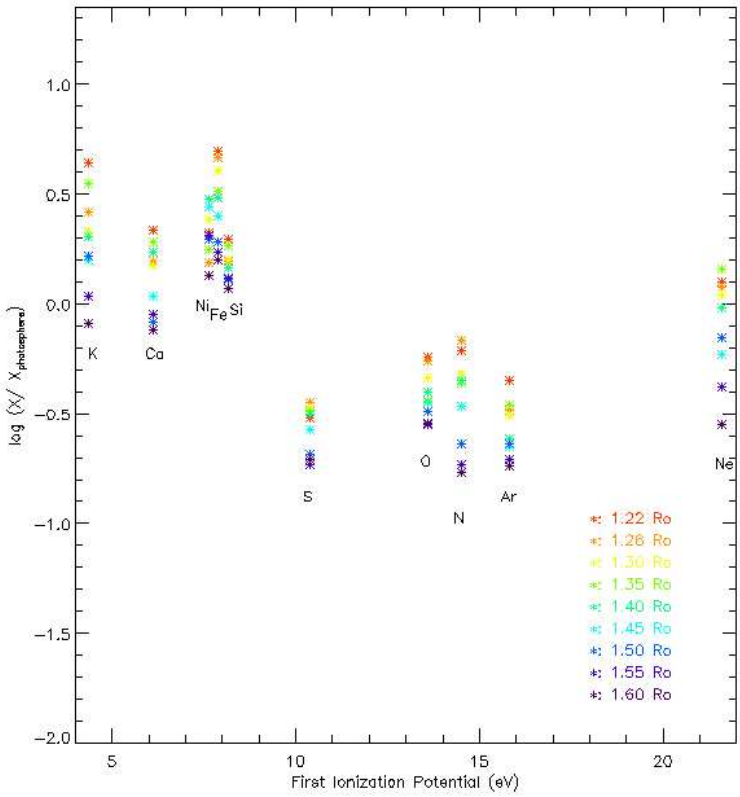
Upper row: 1.5 $R_\odot$, Lower row: 2.25 $R_\odot$

May 1, N pole at bottom left of each panel



Combined FIP and Settling

High Temperature Active Region; Ko et al.

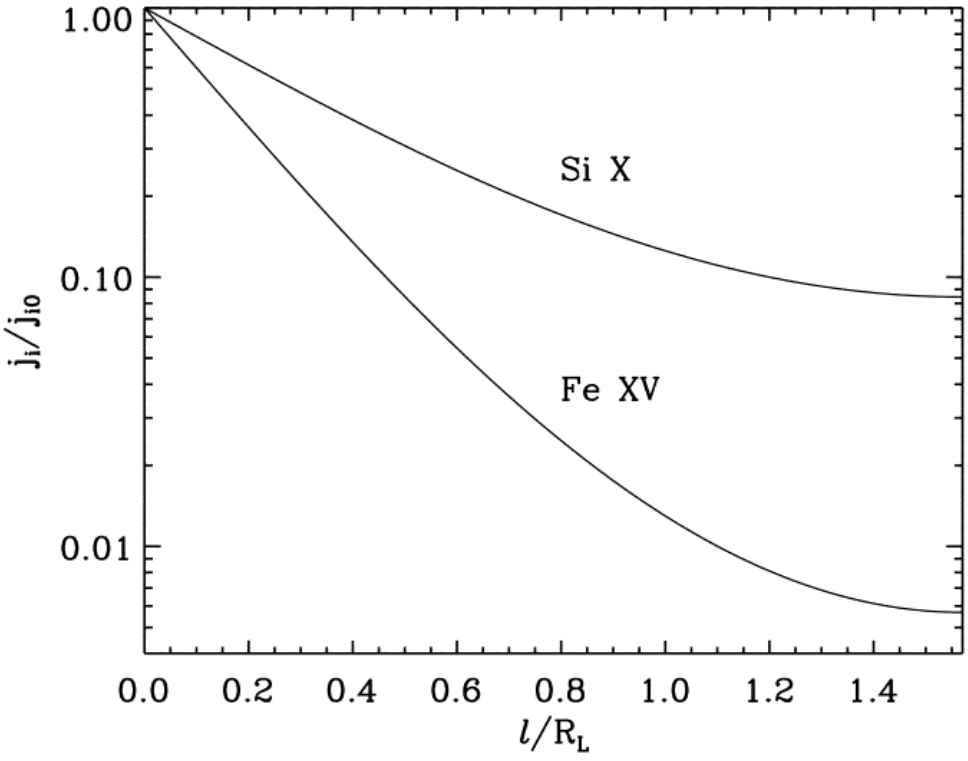


Combination of FIP effect and Gravitational Settling seems to work.

No Clear difference in Scale Height with Mass

Settling Time rather than Scale Height?

Gravitational Settling



Static Theory; Lenz, Lou & Rosner

Scale Height is small even with waves

Settling time $\sim$ 1 day

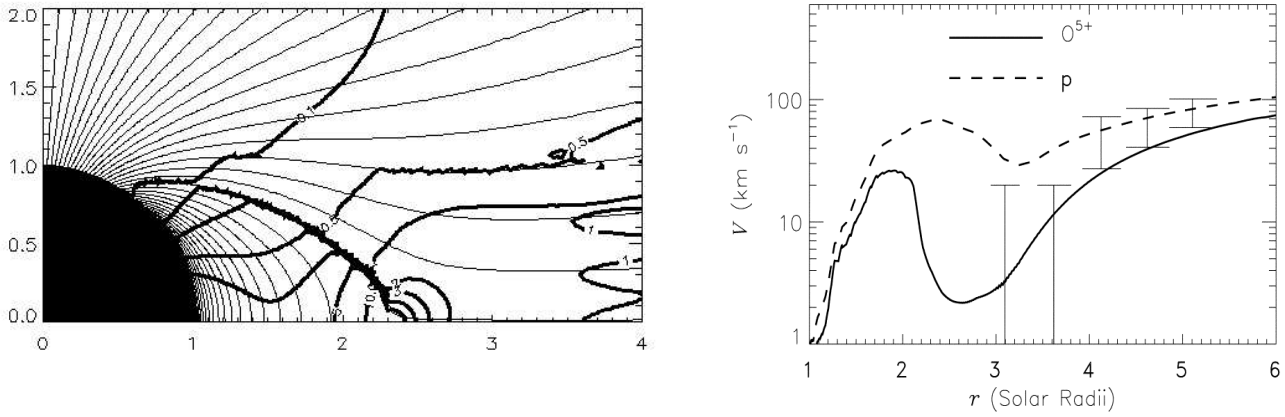
Must replenish streamer core every 1-2 days

Flow Theory; Ofman

Coulomb friction in streamer legs carries oxygen upwards

Abundance Variations

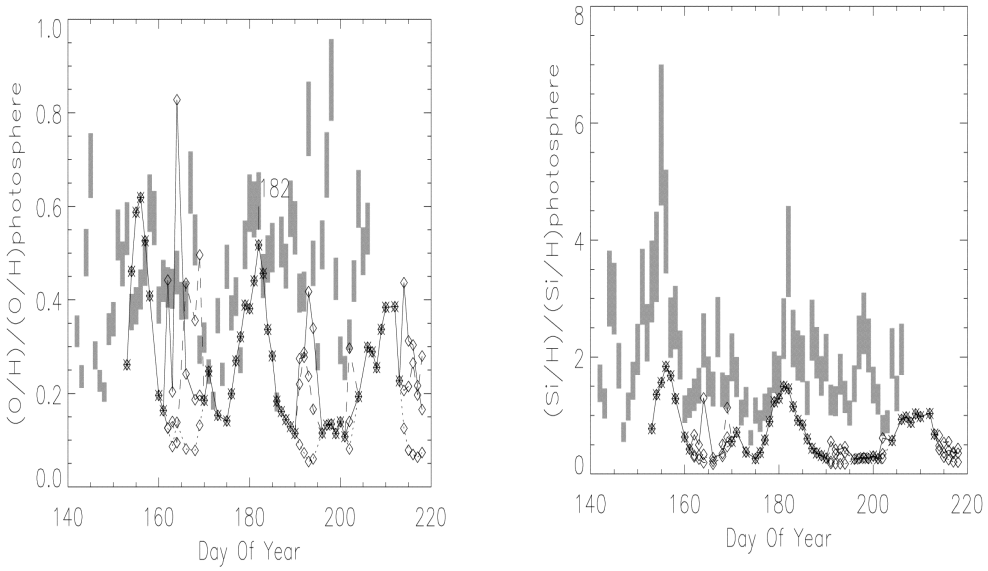
nVA = Constant



Chen et al. 2004

Predict order of magnitude enhancement near cusp!

Comparison with ACE abundances



Uzzo et al. 2003

So-so correlation; ACE outside slow wind or V differences?

SUMMARY

STREAMER TEMPERATURES

- Vary with Height
- Can show Preferential Heating at low n

STREAMER VELOCITIES

- Are higher near the edges
- Increase above about 3 $R_\odot$

STREAMER ABUNDANCES

- Show a FIP bias near 3
- Are low in the core [O/H] ≤ 0.1
  - Should account for Projection
  - Are probably due to Gravitational Settling
  - Are far below slow solar wind values
- Are higher in Legs
  - Sort of agree with Slow Wind
  - Sort of agree with Ion Drag Models
  - Predicted enhancement near cusp