The Formation of the Slow Solar Wind and the Ground State Space Weather

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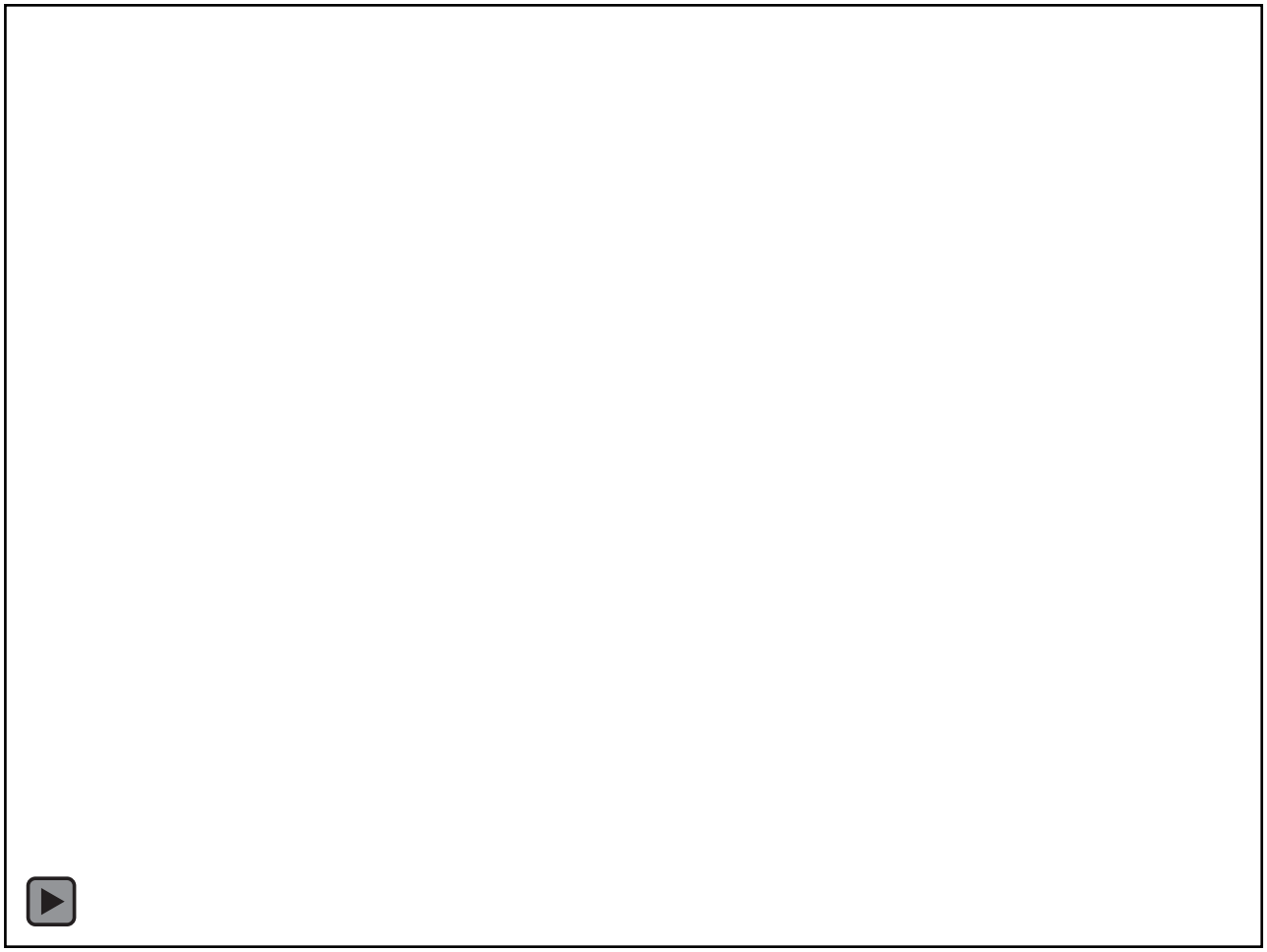
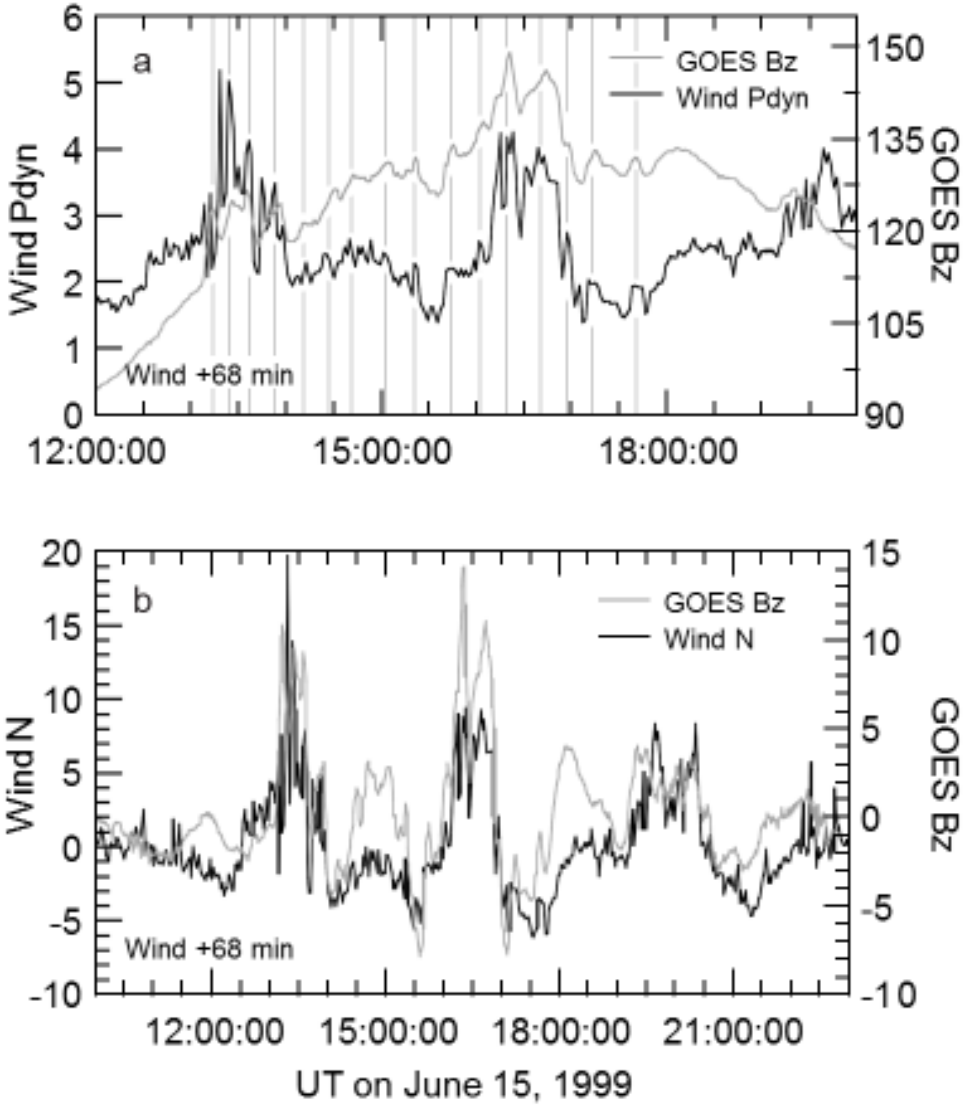
Structures in Solar Wind Density Drive Dynamics in Earth's Magnetosphere



Cyclic SW structures drive ULF waves, affect radiation belt particles

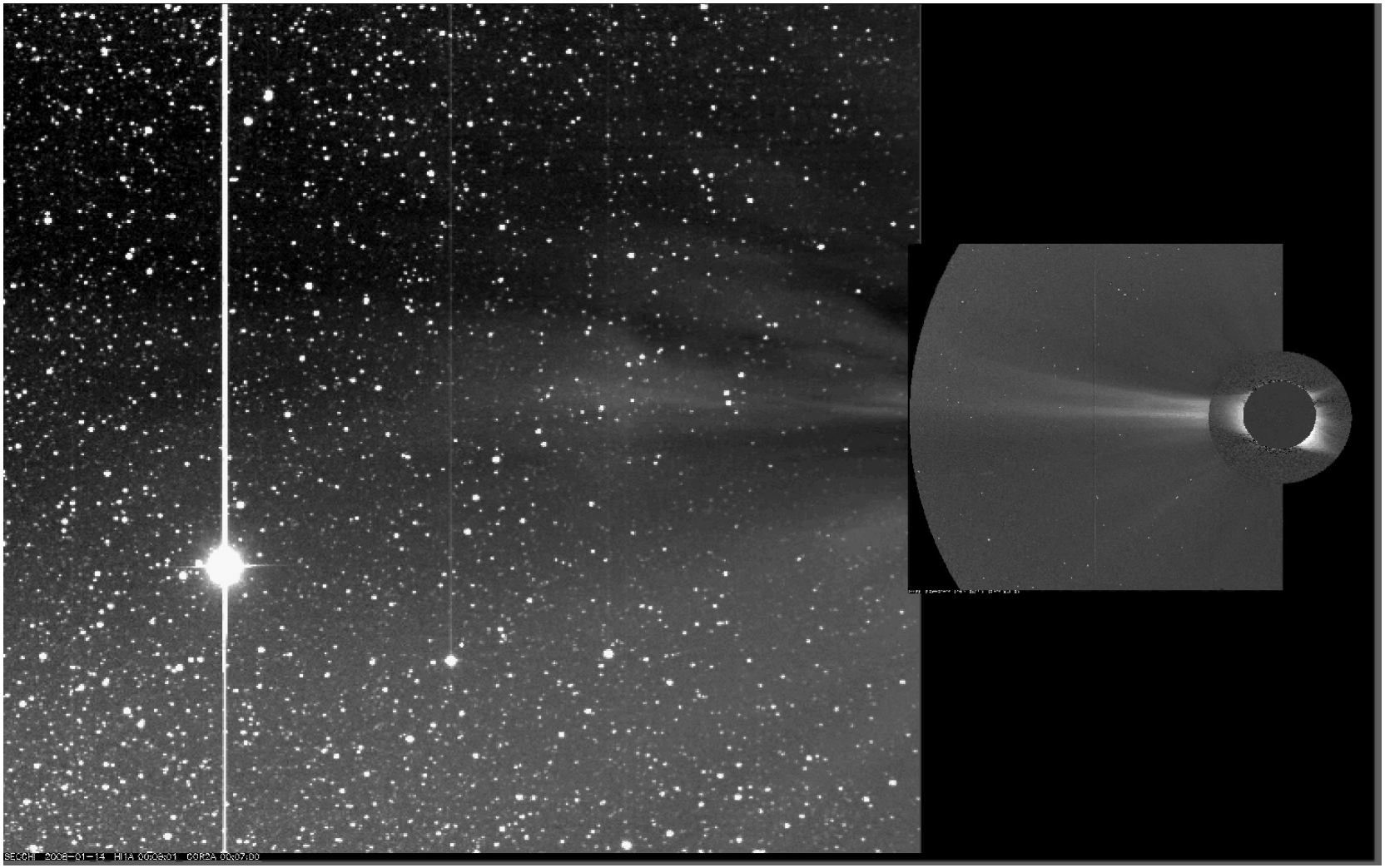
90-minute and 20-minute Variations in Solar Wind at L1 and in Earth's Magnetosphere

- 90-minute quasiperiodic density structures at L1/Wind
- Contains embedded 20-minute quasiperiodic density structures
- The SW drives oscillations in the magnetosphere at the exact same two periodicities (ULF waves)

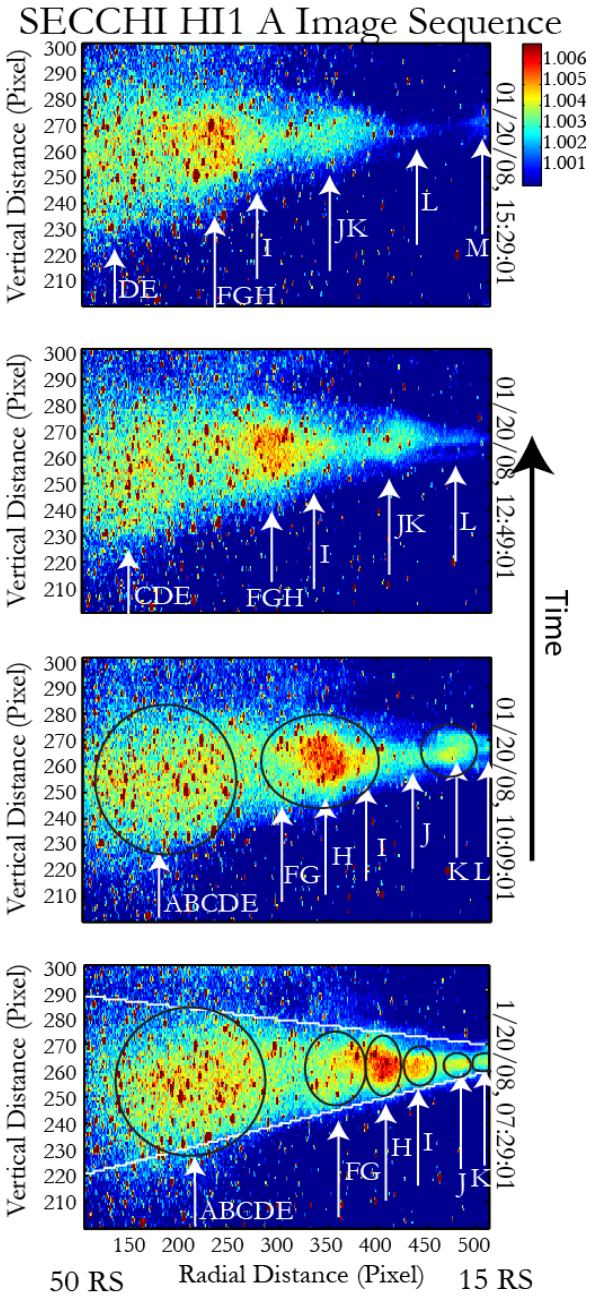


Kepko et al 2002

The Solar Wind is Highly Variable Immediately After its Formation



White light coronagraph/imagers from STEREO/SECCHI
White light = solar wind density

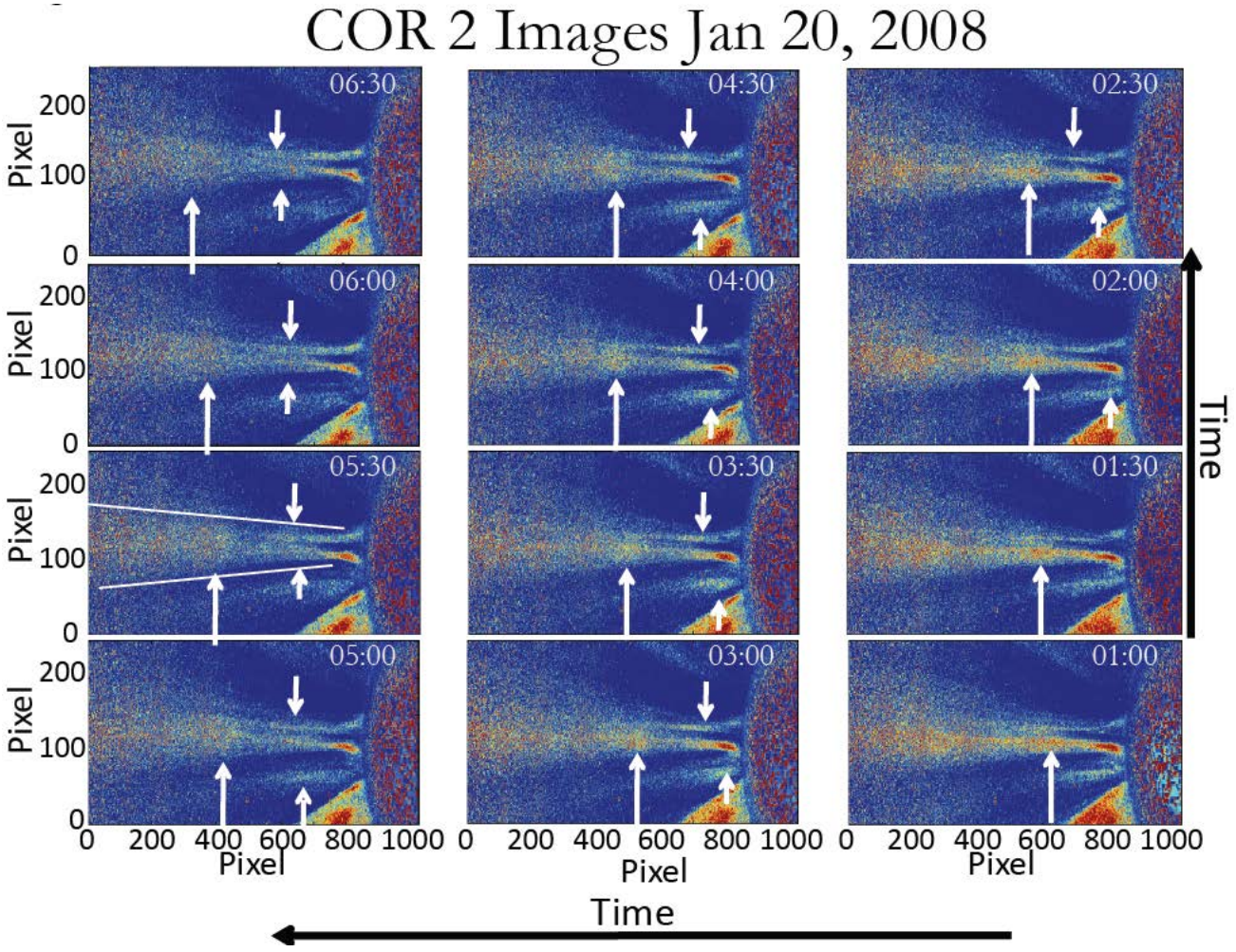


Viall et al. 2010

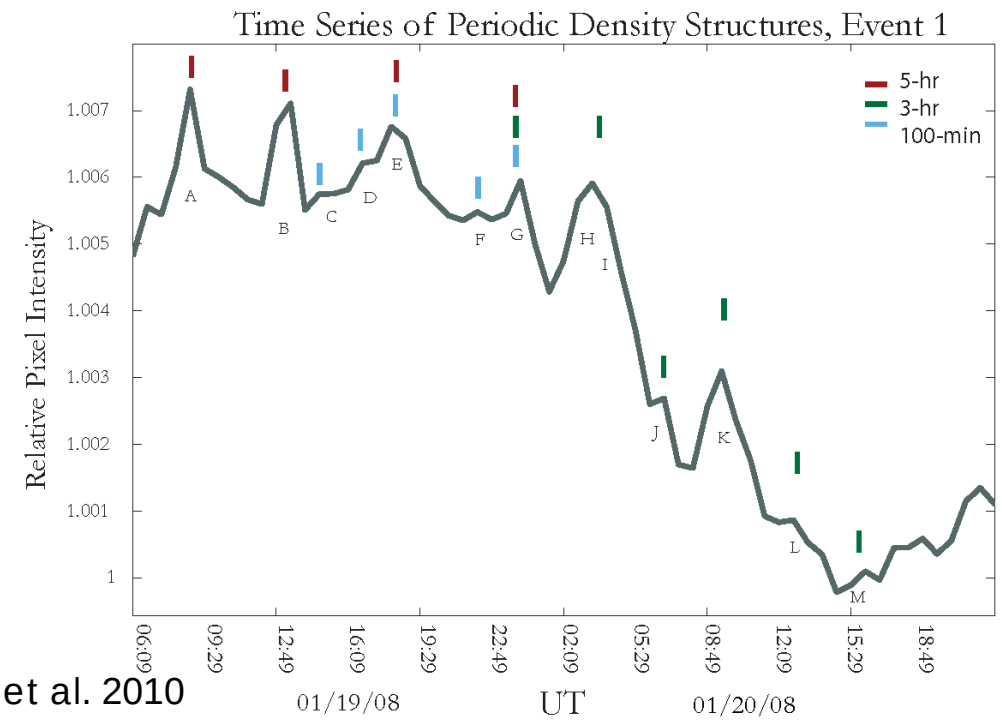
Density Structures in the Slow Solar Wind are Periodic

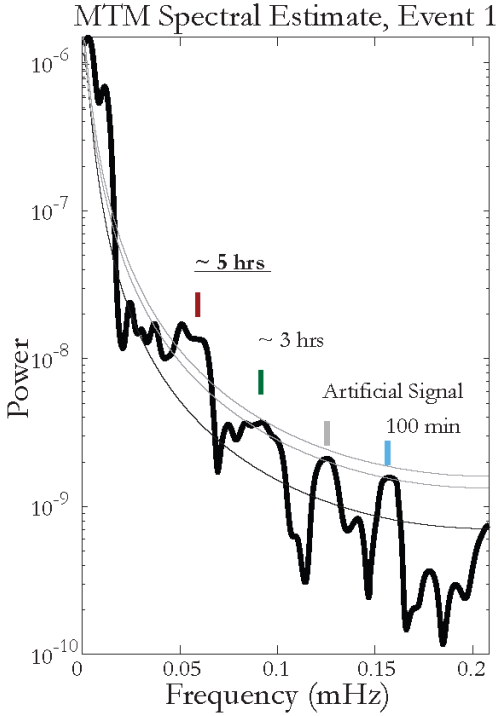
- Zoom-in and look at a series of still images beyond trans sonic point
- Shows small-scale density structures continually emitted
- Regular, periodic train of density enhancements
- Smaller periodic density structures (~1000 Mm) are embedded within larger ones

Periodic Density Structures are Formed at or Below 2.5 Solar Radii



Density Structures in the Slow Solar Wind are (quasi) Periodic

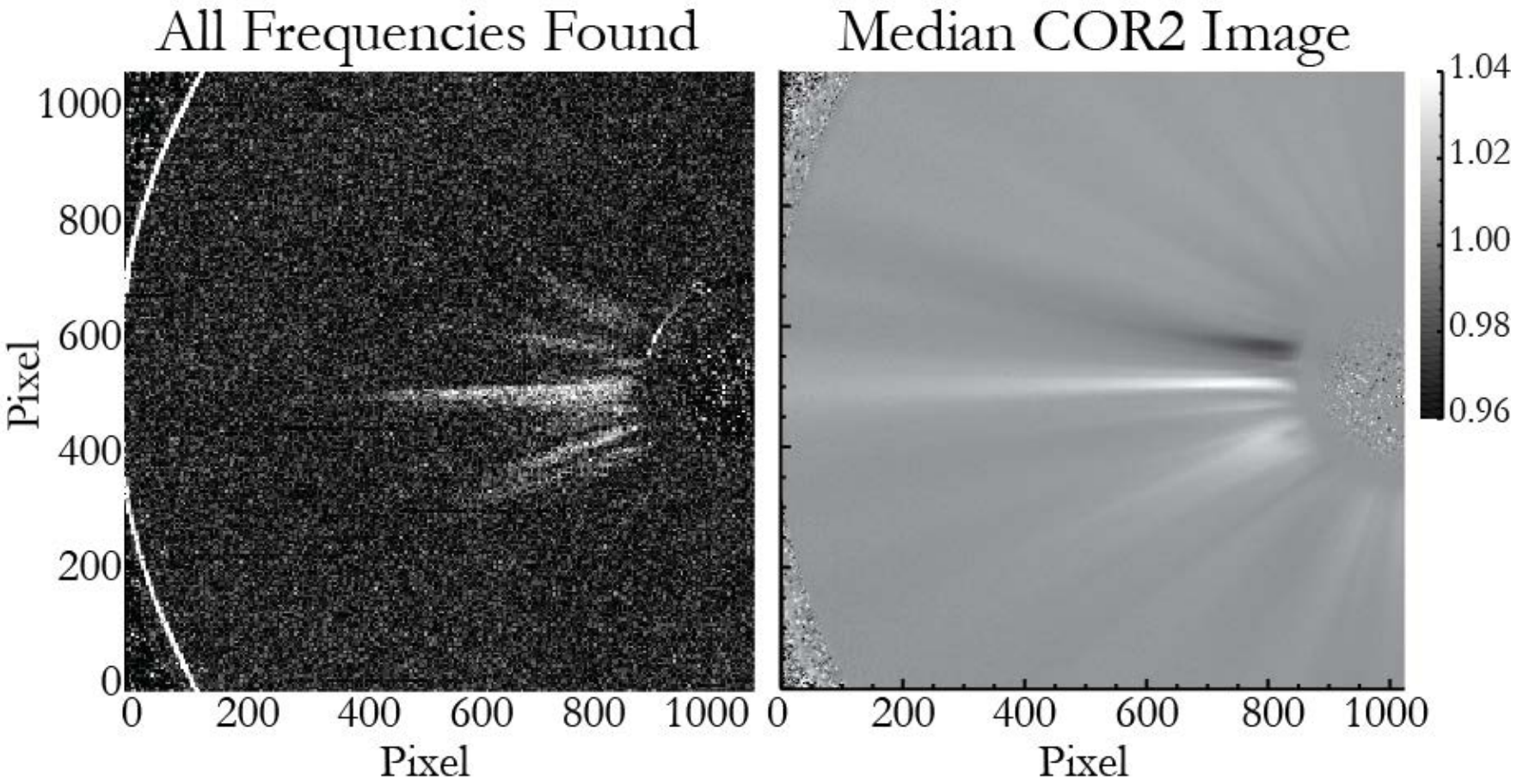




Viall et al. 2010

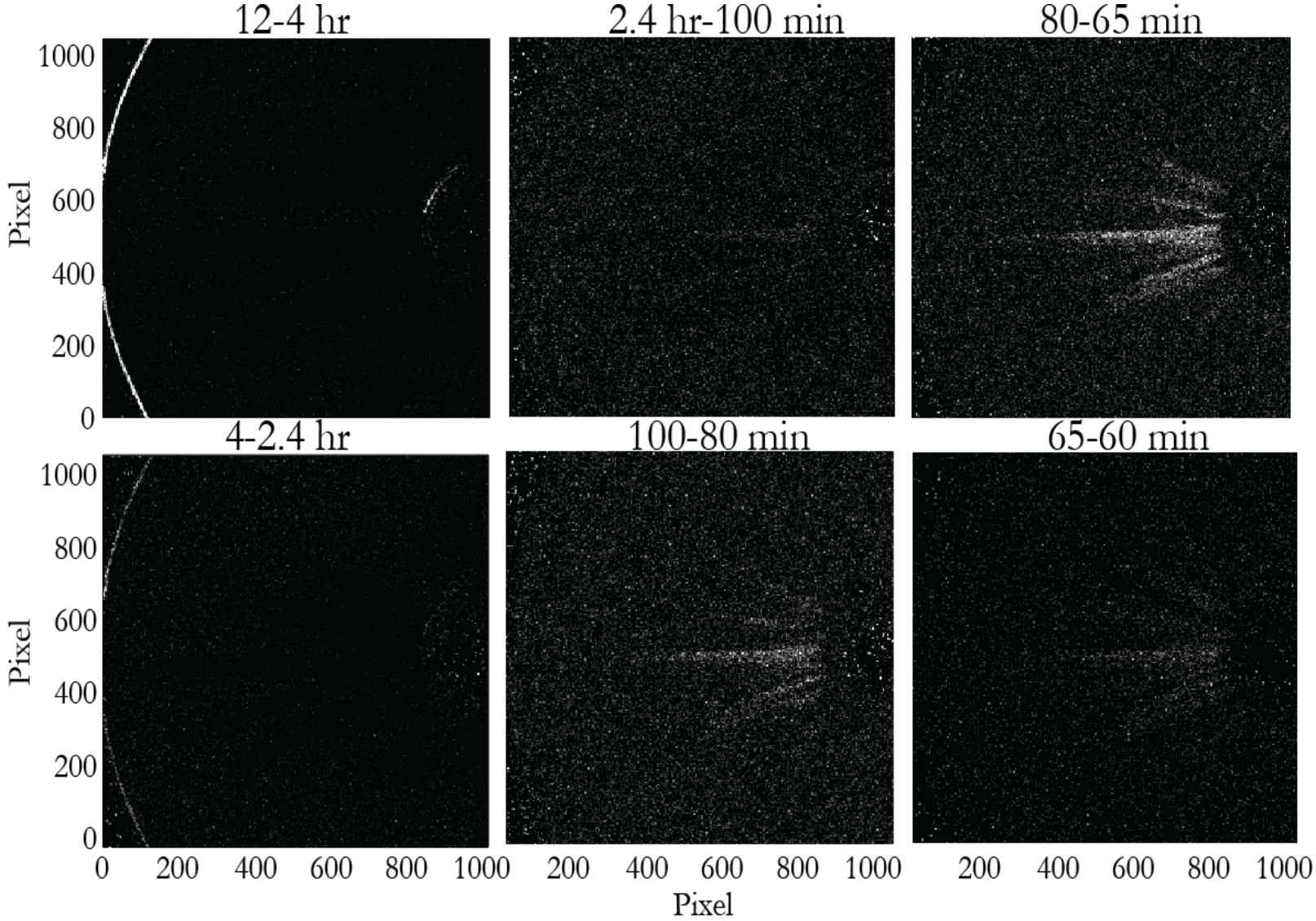
- Time series of density in a slit of pixels at 15 solar radii
- The periodic structures all pass through these pixels as they enter the field of view and advect outwards. Like being 'in situ' S/C
- Though not a 'wave', the periodic nature confirmed in spectral analysis (Thomson 1982; Mann & Lees 1996; Viall et al. 2008)
- Periodic nature useful to distinguish from random fluctuations/turbulence
- Periodicity important information on physics of their formation

Periodic Density Structures Associated with Streamers



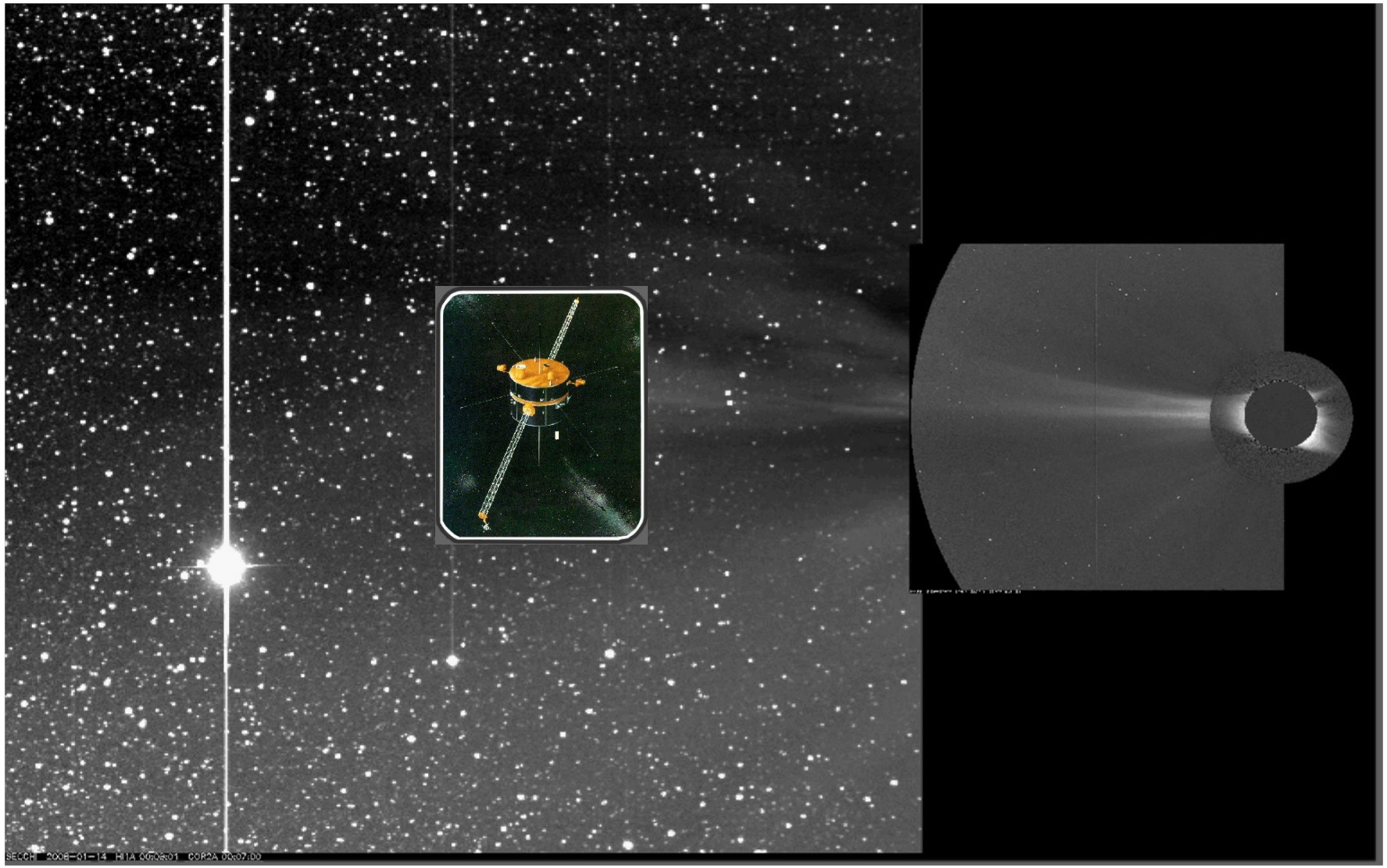
- 24-hr time series at every pixel- spectral test for discrete frequencies; showing frequency map for one day and median image for same day
- Frequency map: white = periodic density structures; black = no discrete frequencies
- All concentrations of periodic density structures associated with streamers; not all streamers produce concentrations of periodic density structures on a given day

Periodic Density Structures Occur with a Characteristic Timescale of ~80 minutes



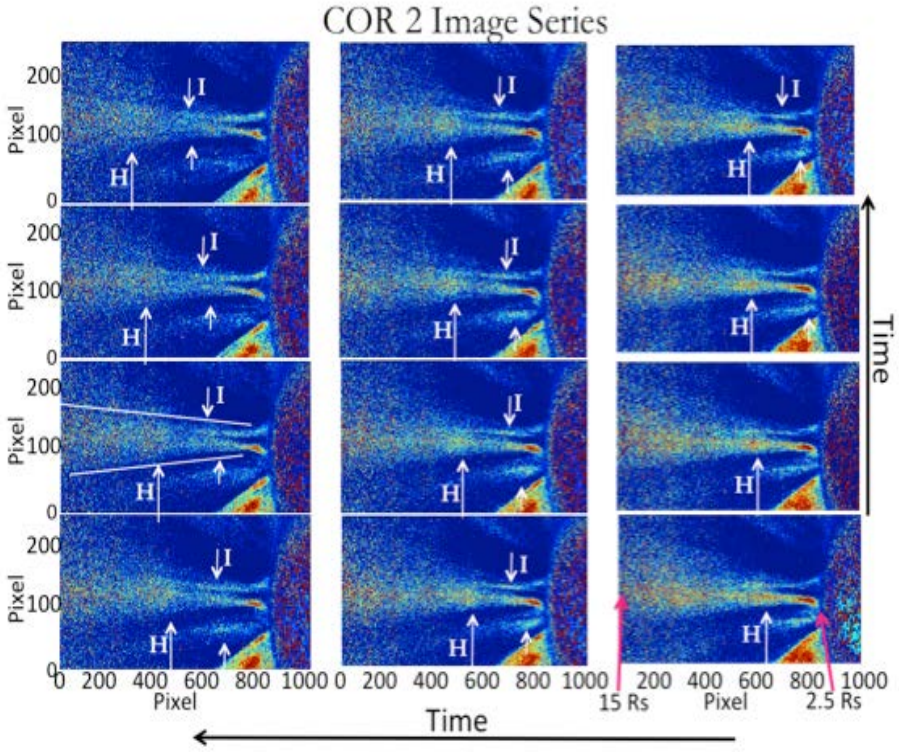
White: discrete frequency in that band; Black: no discrete frequencies

What are the Plasma Properties of Periodic Density Structures ?



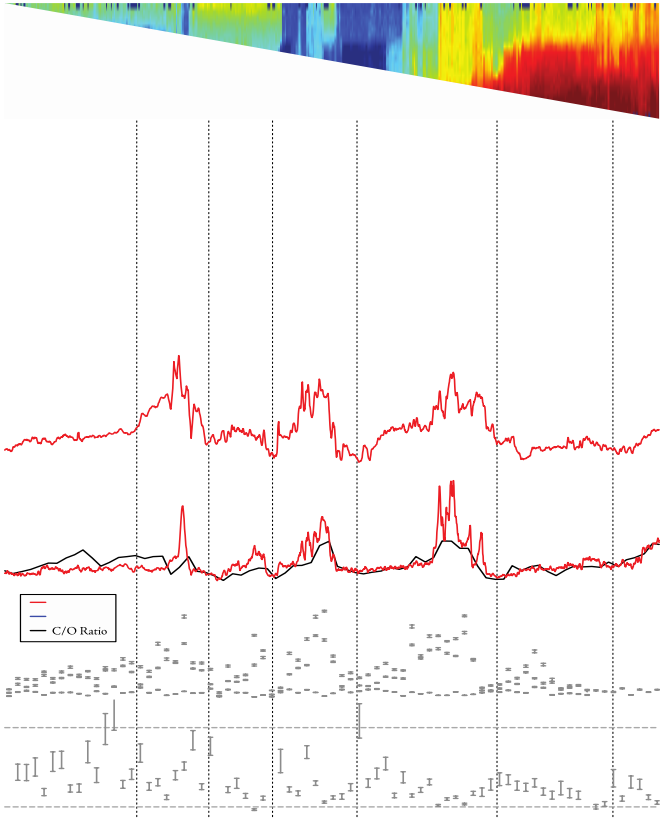
Next up: *In situ* observations give us more clues about the formation/source of the structures

COR2 – 90 minutes ‘blobs’ at Helmet Streamers



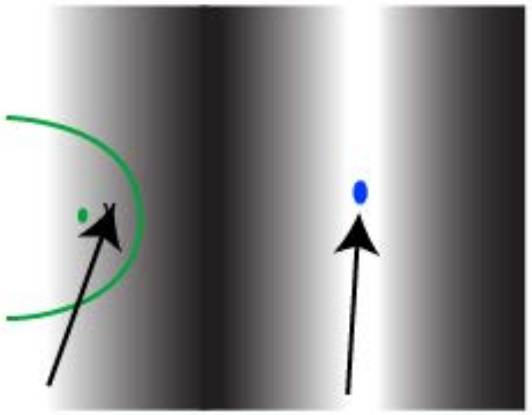
Viall & Vourlidas 2015, ApJ

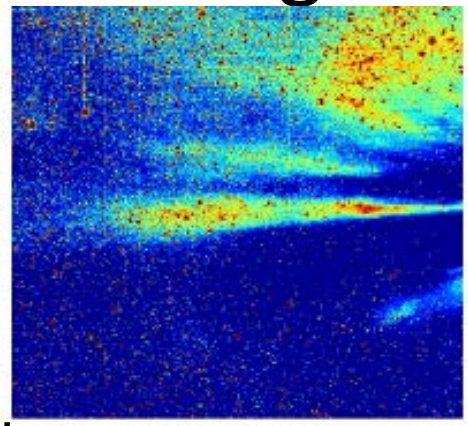
90-minute structures with ACE high cadence data confirms solar source

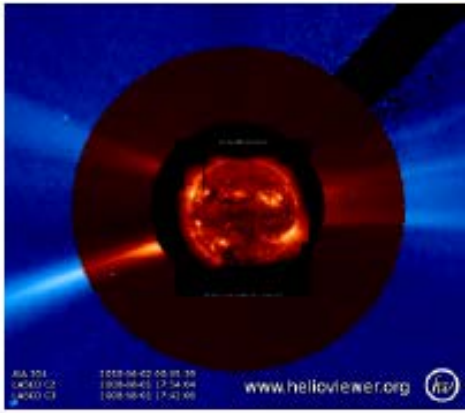


Kepko et al 2016

Linking coronal variability with structures in solar wind hitting Earth.



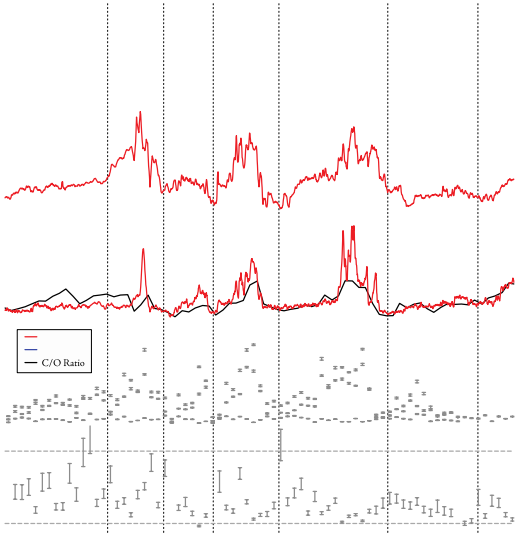




GOES Spacecraft

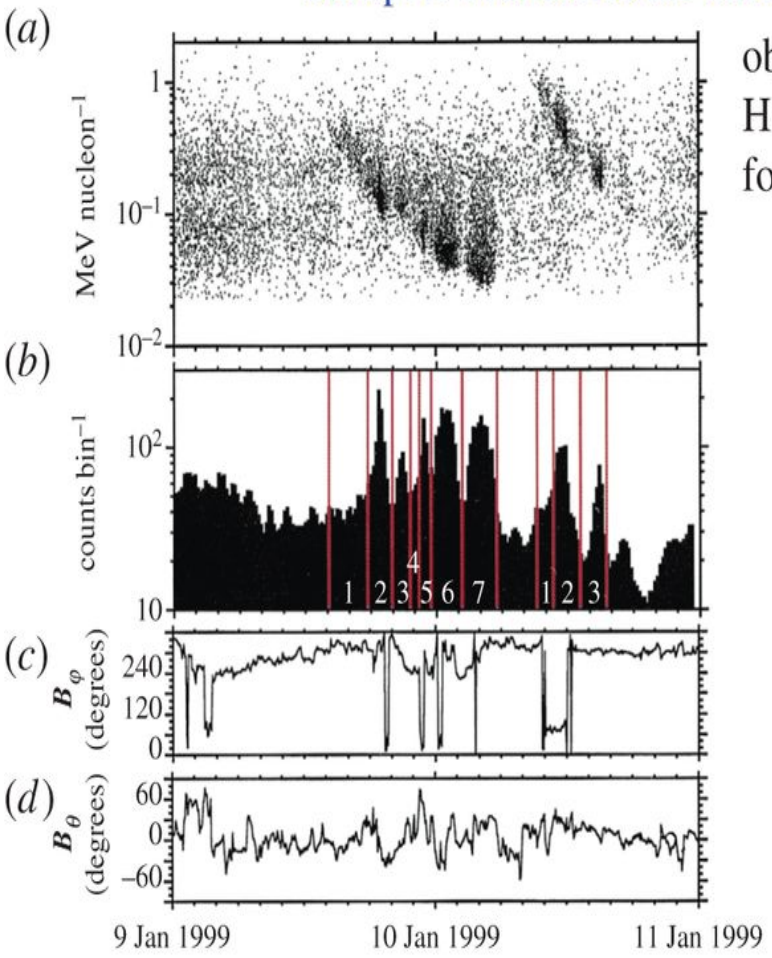
L1 Observatories

Current observational gap



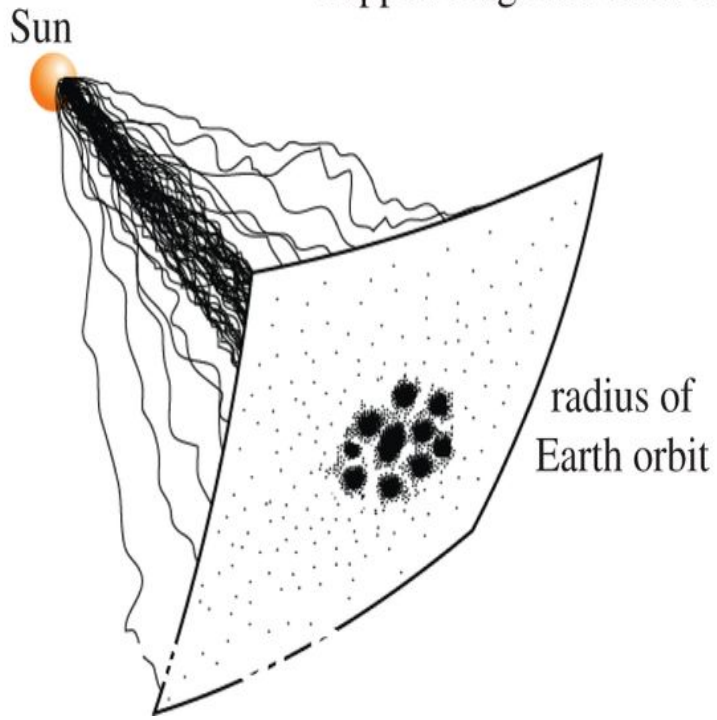
Structures in the solar wind are the medium through which CMEs and SEPs propagate

transport boundaries are observed: 'dropouts' of solar energetic particles



observation of
H-FE ions versus arrival time
for 9 Jan 1999 SEP event

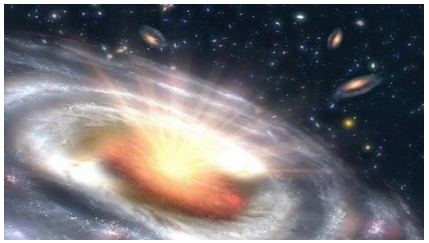
theoretical model-based
trapped magnetic field lines



Mazur et al 2000

‘Small Things Can do Big Damage’

Small Blackholes



Small Dogs

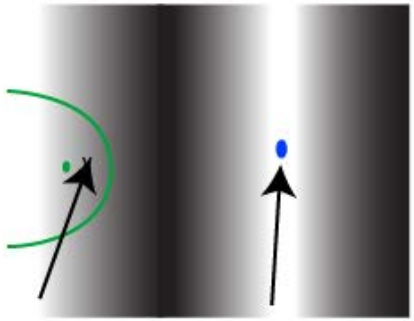
Small Kids

Small Carpenter Ants

Small Hail

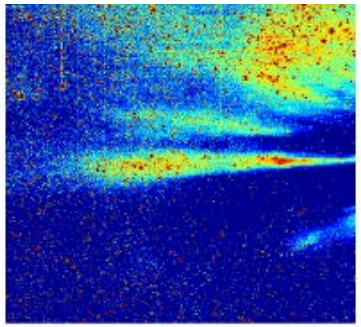
‘Small’ Structures from the Sun-
which are constantly emitted-
can have big, cumulative, impacts on
Earth (terrestrial planets in general)

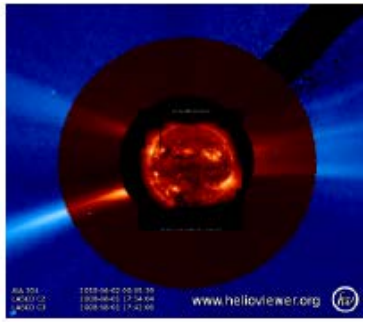
Small leaks



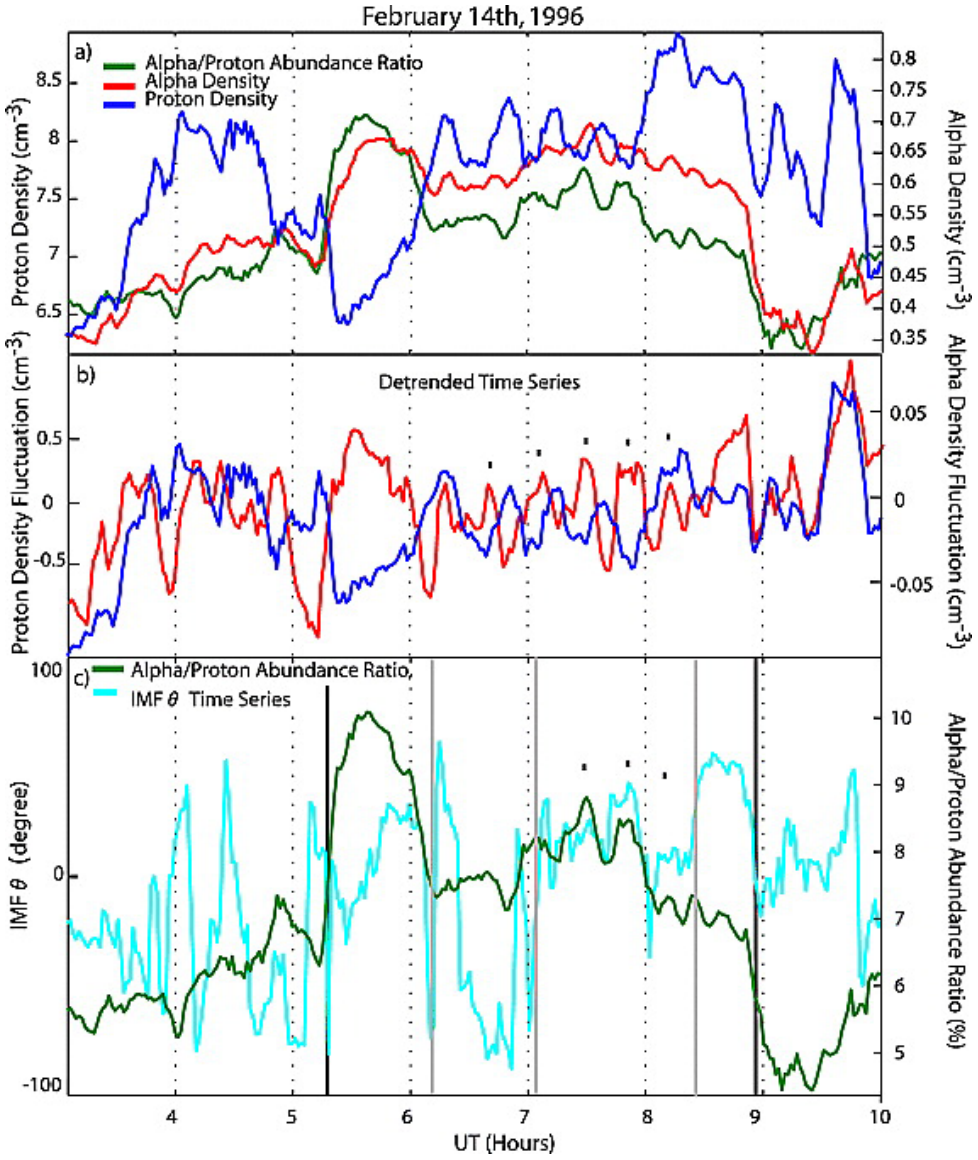
GOES Spacecraft

L1 Observatories





L1 Wind Alpha Data Show 30-minute/850 Mm Structures Created in Corona

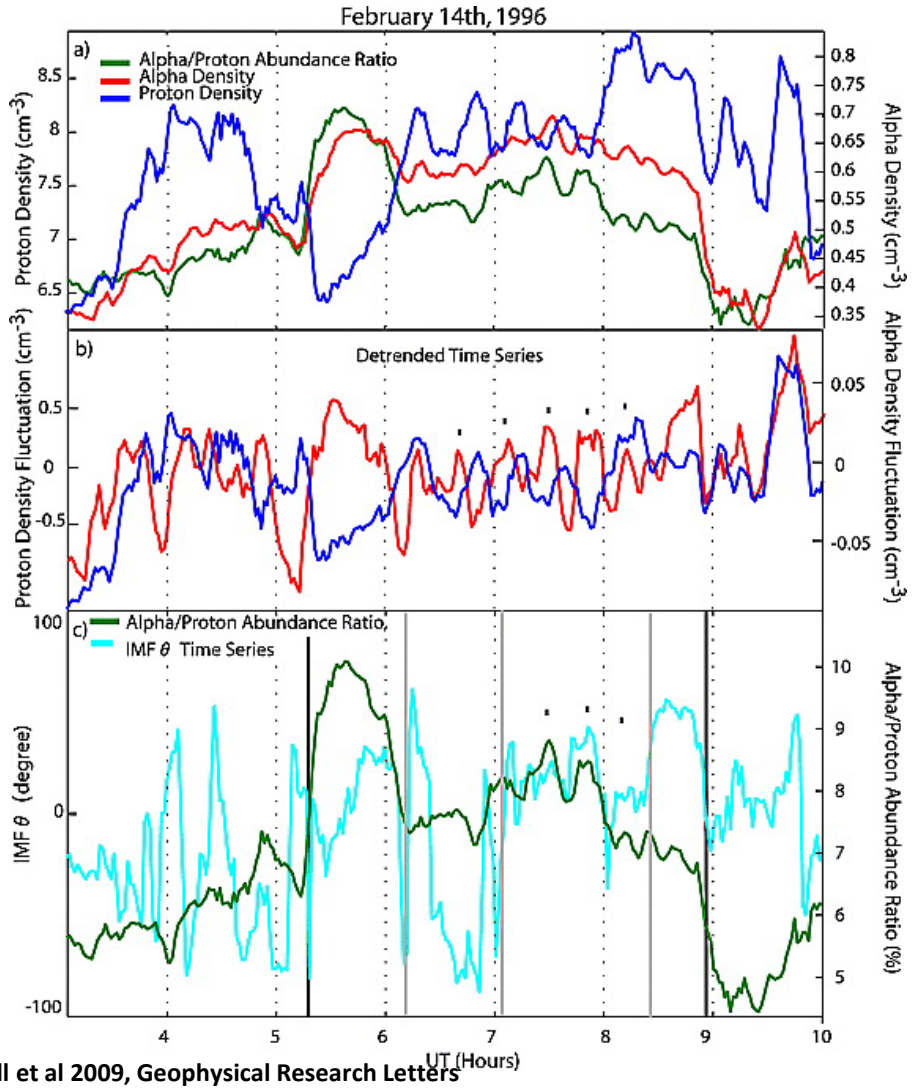


a) Periodic density structure in the proton and alpha time series

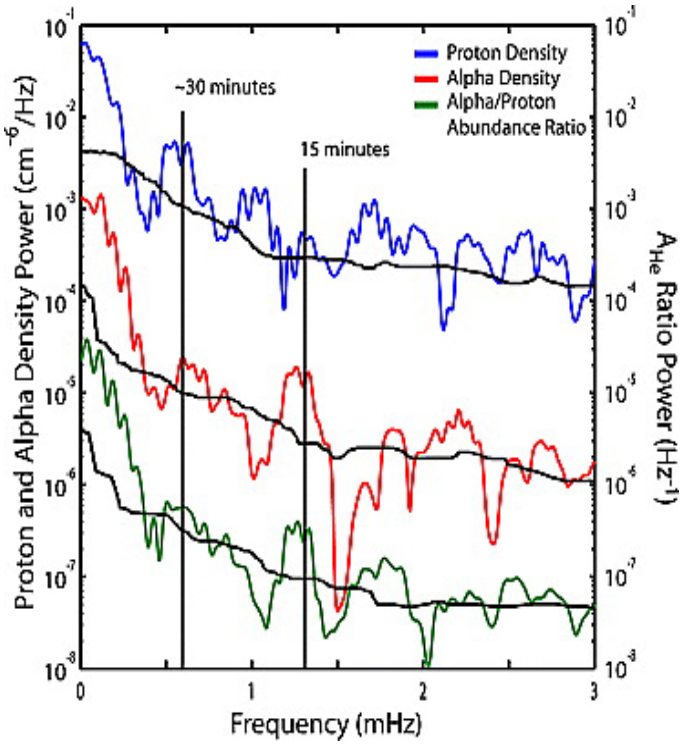
b) Detrended time series to identify more clearly the 30-minute periodicity - they are in anti-phase

c) B field rotations are often correlated with composition boundaries, but not in a predictable way.

Fourier Analysis is Useful Tool to Identify Characteristic Scale Sizes

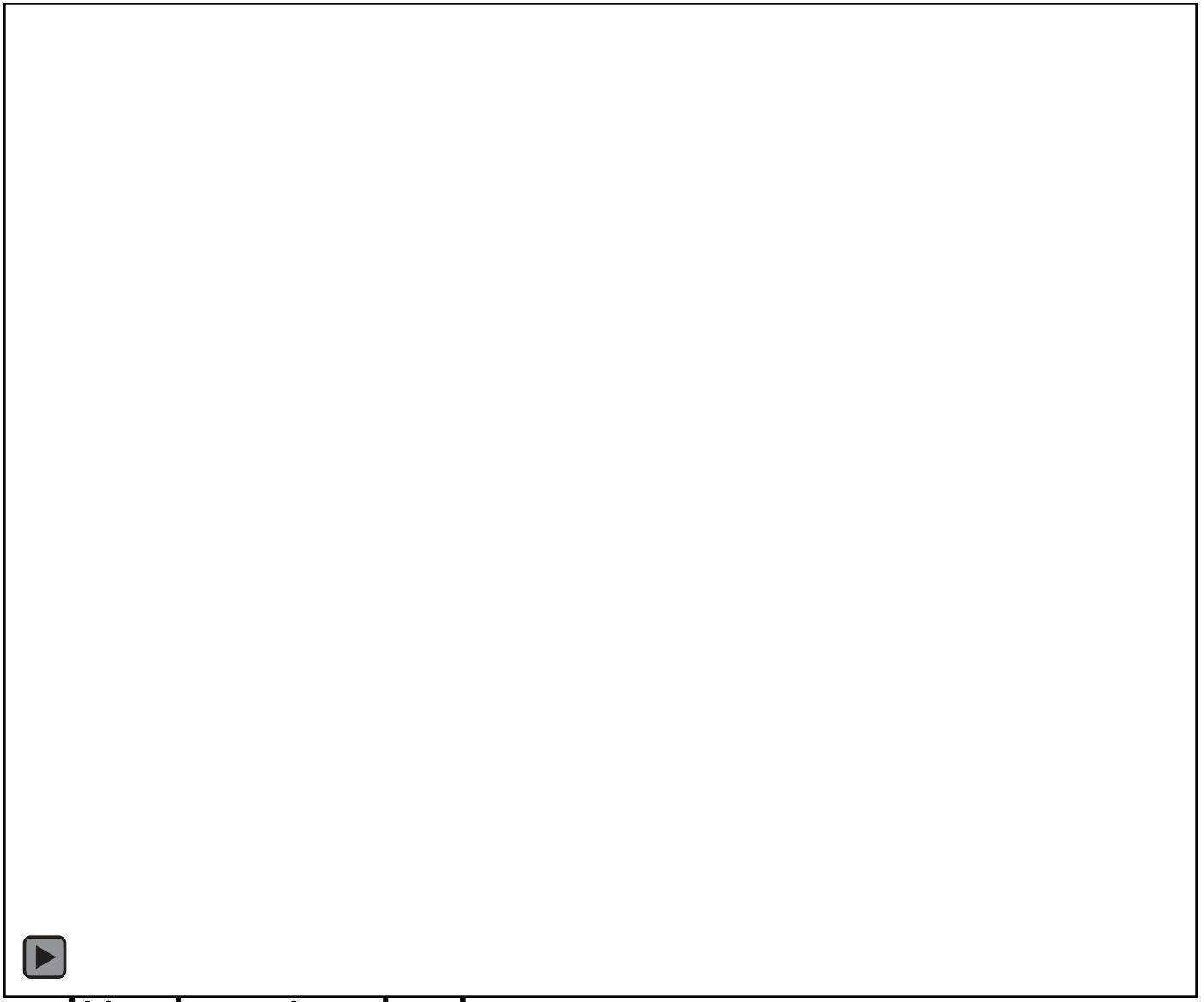


Viall et al 2009, Geophysical Research Letters



The solar wind plasma source is changing in a periodic nature creating 30-minute (850 Mm) structures

DeForest et al. COR2 Deep Field Exposures Show Solar Wind Structures Down to the Resolution Limit for the First Time



- Submitted yesterday!

DeForest et al. COR2 Deep Field Exposures Show Solar Wind Structures Down to the Resolution Limit for the First Time …

Including density structures released with a characteristic 20-minute timescale