

CONCLUSIONS FOR RESEARCH PROJECT 8/7/2013

To get a good sense of our conclusions, please read the latest draft of the research paper we wrote along with my cumulative mini-reports and summaries. Here, however, is the results of what we found in brief.

What are the nature of Type II Spicules?

DATA: Taken over a period of 20 minutes in 2010 by the Dunn Solar Telescope at the National Solar Observatory. Around 875 individual frames: some of which are red-wing (+1.1 angstrom above Ha) and some of which are blue-wing (-1.1 angstrom below Ha) timeseries. Some are wavelength scans of varying wavelengths in Ha, Ca II from -1.7 angstroms below to +1.7 angstroms above. 1s cadence and very high resolution. This is the limb of the Sun, other Type II Spicule studies are usually done more at the Sun's belly (disk center)

-There is definitely a difference between red-shifted and blue-shifted fibrils taken at this certain region of the sun moving relative to our line of sight.

-Redshifted fibrils appear more often and are never really overlap with blue fibrils (red ones are higher and more elongated).

-It is possible that, due to pressure differences and changes at that region and due to the rotation of the Sun, red-shifted fibrils will be favored and will appear more often and be bigger. The rotation of the Sun means that instead of -1.1, +1.1 blue, red, we actually see absorption at -1.3, +.98 blue, red about the H-Alpha line. We know that redder wavelengths are less easily scattered (why the sky is blue, sunsets are red!). We are thus seeing higher in the Sun's atmosphere with the red fibrils as the radiation comes from the interior and it is possible that the higher fibrils are longer? One possible idea. Their general appearance/motion is favored by pressure balances in the chromosphere and the general rotation of the Sun. HORIZONTAL MOTION IS FAVORED!!

-By observing the mapped spectral intensities of the wavelength scans, we found that any fibril has absorption peaks at +/- 1.1 (what should be, at least, with solar rotation being taken into account) H-Alpha light. This indicates some thermal/Doppler broadening, stuff is moving in the fibrils to broaden it in general. There is also a lack of symmetry in the mapped spectral intensities: some are darker towards the blue, while some are darker towards the red. This lack of symmetry suggests a general direction of motion for the 'stuff'- red-shifted or blue-shifted. This matches up with what we observed!

-We did not observe the gradients of black and white indicating accelerated flux tubes when we subtracted Ca from H-Alpha images (different velocities for each sort of image). We found one maybe example (it may turn out to show two separated flux tubes, not one continuous one!). One or none, this is a big strike against the flux tube of accelerated plasma theory if we didn't observe a main implication!

-When we looked at one image in H-Alpha corresponding to a certain red-shift, we saw fibrils. When we calculated the corresponding Ca II redshifted wavelength for the same velocity, we did not see any fibrils! This taught us more about the chromosphere: the

matter in it is such that H-Alpha is more easily absorbed than is Ca II radiation (mean free path, all that good stuff).

-There might be a connection between what we are seeing in the chromosphere and matter/magnetic field lines in the chromosphere. Phil plotted a coronal image over a few of our chromospheric images and the coronal 'stuff' seems to hover over our fibrils and match it rather well! This might be a future interesting point worth exploring.

-Plasma sheets might help explain the coronal heating problem/ transfer of energy between chromosphere, transition region, and corona. You wouldn't cook your dinner using a very hot pinhead. Maybe a sheet of hot plasma could explain how heat is transferred from chromosphere to corona/TR/ etc!? Maybe it is getting from the corona TO the chromosphere, rather than shuttled UP by waves (Alfvenic, otherwise?) from chromosphere to corona?

-Phil had the idea that STUFF IS MOVING FROM CORONA TO CHROMOSPHERE (energy, etc) rather than the other way around. Corona/chromosphere correlation makes it appear that way, how the 'stuff' is connected.

-POSSIBLY: Idea of cyclones might supersede plasma sheet idea (red and blue fibrils are close, possibly rotational motion), but red>blue- not balanced. For actual cyclone, we should see symmetry. Not sure about this, but no symmetry so maybe no?

WE THINK WE MIGHT HAVE DISPROVED THE FLUX TUBE PICTURE

-In general, the idea of plasmatic standing waves implies that there must be nodes and thus variations of velocities along the supposed plasmatic flux tube (velocity=0 at the nodes, maximum at the humps). We should thus see a gradient of grays when we observe it in varying absorption wavelengths due to the different velocities. But we don't, as Phil put it, 'they look like uniformly dark logs!!'.

-Few/none of the proposed accelerated flux tubes were observed, as I mentioned earlier!

-Scientists have to add more and more complexities of motion to the flux tube picture- to the point where we seem to be getting 'epicycle upon epicycle!' (torsional motion, linear plasma shooting up or down, swaying motion!)

-Megameters of material light up within a few seconds- in order for this to occur, stuff would have to be traveling faster than the Alfven speed for waves measured in this region of the chromosphere (super-Alfvenic).

IN SUMMARY, THE SHEET PICTURE

-Like your grandma's lace curtains blowing in the wind: sometimes they look transparent and other times, they bunch up to look opaque.

-A potential Occam's Razor for this difficult motion and scenario.

-Plasma sheets result due to tangential discontinuities coming from the weak solutions to equations of magnetohydrodynamics- need to take those into account.

-Parker postulated these could occur since the 1970s- maybe this is the prophecy being fulfilled!

- Possible alternative explanation/contributor for the heat transfer in the solar atmosphere.
- Maybe flux tubes can explain some of these Type II Spicules, but for others, sheets might fit the bill better.
- Flux tubes picture getting rather full of complications, qualifications, consternations with the advent of new data. Occam's Razor, please!?!
- Maybe we can disprove (have disproved this summer?) the flux tube picture, but it might be hard to 'prove' sheet picture. Maybe need magnetic field measurements/ magnetic flux measurements? At least, we haven't disproved sheets!
- Made some good movies of what we believe to be possible examples of both pictures/ models (coexistence?!?).
- Our picture is fair and based upon good science. We deserve to have our ideas respected and taken into account, not dismissed!

FUTURE PLANS

- Work on paper, edit, finish good version, send to Kevin for more edits, revise, send to Astrophysical Journal.
- Work with data some more, get more out of it?
- New measurements, different region, or magnetic field/flux measurements?
- Continue to try and disprove either picture.
- Continue to challenge flux tube picture.
- Continue to advocate for our sheet model to be respected/considered.
- Continue to practice GOOD SCIENCE!!!!!!!!!!