Hα IS EASY
Hα FIBRILS ARE CONTRAILS

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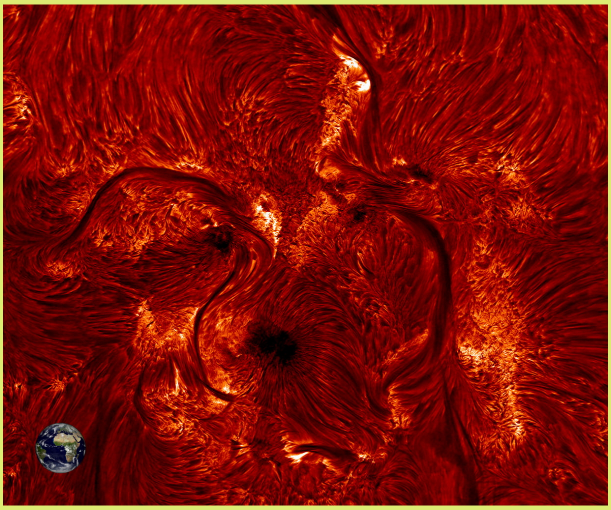
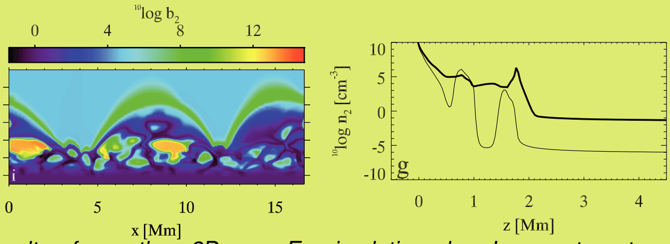
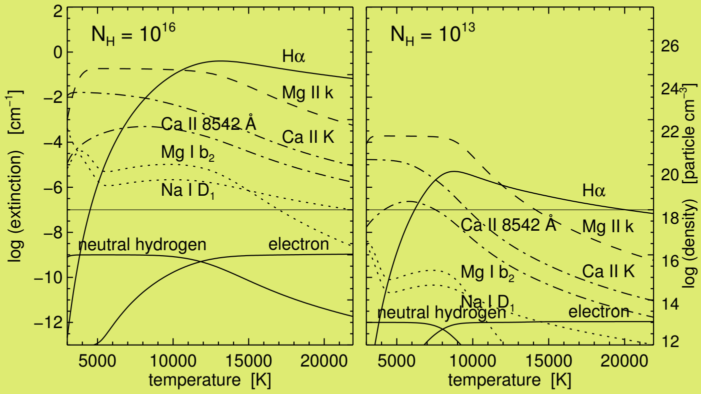
- Hα is easy! The Hα opacity is well described by assuming LTE, but not at the present location and time but for the hottest instance nearby ($\approx$ 500 km) in the recent past ($\approx$ 5 minutes). The Hα source function is a standard two-level scattering one.
- Hα fibrils are contrails! The long fibrils seen in Hα everywhere where there is some activity are not flux tubes or sheet folds or density ridges but contrails. As from airplanes in the sky. They are the wake that becomes visible after a brief but very hot heating event has passed. They do not outline the azimuthal component of current field lines, but of past field topography.



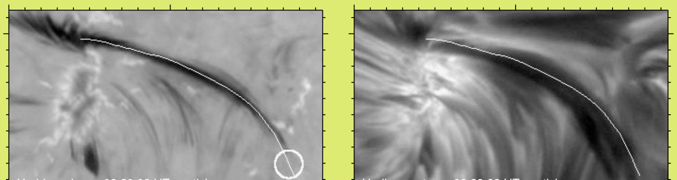
Mosaic of Hα images taken with the DOT by Pit Sütterlin on August 8, 2005. The Hα chromosphere consists of a dense mass of fibrils wherever there is activity. The fibrils seem to outline azimuthal field components. No other spectral line shows these fibrils at such length: Ca II 8542 Å and He II 304 Å only show their beginnings, Lyα only their ends. Why is Hα such an extraordinary diagnostic?



Results from the 2D non-E simulation by Leenaarts et al. 2007A&A...473..625L. The H I n=2 level lies at very high excitation energy (10 eV) and senses only the far tail of the Maxwell distribution in collisional excitation. Therefore, the recombination balancing in cooling gas after hot shock passages is slow (Carlsson & Stein 2002ApJ...572..626C), slower than the typical 3–5 minute shock repetitivity in the chromosphere. As a result, the n=2 population (Hα opacity) stays at the high LTE values reached in the shocks (right; upper curve non-E, lower curve LTE). In cool aftermaths the NLTE overpopulation can reach enormous values, as high as 10^{12} (orange clapotispheric clouds at left). In this simulation the shocks reached only about 10^4 K, but the actual heating events that cause spicules-II and similarly (but more horizontally) long Hα fibrils are visible in AIA 171 Å and 193 Å and so must become much hotter. It is a good assumption to adopt the Hα opacity at such hot brief moments also during the cooling aftermaths. Similarly, Lyα scattering produces spatial boosting of the Hα opacity to larger values reached in nearby hot gas (Rutten & Uitenbroek 2012A&A...540A..86R). Sluggish recombination and Lyα scattering work together. So: just assume LTE! But only for the hottest moments nearby in the near past. Then simply maintain those peak population values. What a simple recipe! Easy!



LTE extinction against temperature for chromospheric lines for hydrogen densities bracketing the photosphere and chromosphere. A simple undergraduate Saha-Boltzmann exercise. Example: Mg II k extinction first increases through Mg I ionization, then has a plateau where all Mg is Mg II, and then shows a steep decline from ionization to Mg III. The same for Ca II K, but at 18× lower abundance. Hα is the weird outcast! Thanks to its combination of very high excitation energy, the enormous hydrogen abundance, and lack of higher ionization stages. Above 12 000 K Hα becomes the strongest line of all! Thus, if some gas parcel gets very hot it gets extremely opaque in Hα. And stays so for minutes thereafter.



Two Hα filtergrams from SST/CRISP data taken by Luc Rouppe van der Voort on June 21, 2014. I co-aligned SDO/AIA and found that the Hα-wing fibril at left outlined the track of a heating event. The circle is at the extra-bright tadpole-like tip of a bright streak I saw rapidly extending in AIA 304, 171, and 193 Å. The white curve marks its path. The Hα wing was so dark because the line core was very wide, probably from thermal broadening. Three minutes later the AIA streak and the Hα-wing fibril were gone, but instead a very dark fat fibril had developed at Hα line center (right). The gas had cooled and recombined, giving enormous persistent Hα opacity. This event was much like a spicule-II, but with a more horizontal trajectory.

- Hα serves as a wide black marker pen for small fast hot events.
- Yet smaller and faster heating events are not visible at AIA resolution. I suspect that all Hα fibrils other than dynamic fibrils are made this way. Filaments also. Visible as aftermath Hα contrails.
- What are the heating agents? Likely torsion kicking gives more carrying length than the p-mode undulations sloshing up dynamic fibrils in fluxtubes. The tadpole-like heating suggests a magnetic agent (component reconnection? Alfvén waves?).