THE CHROMOSPHERE WITH DOT AND SOT

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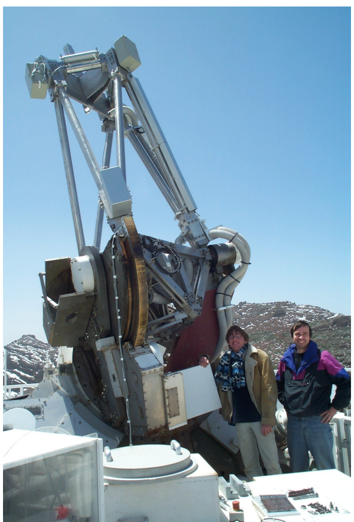
- *chromosphere with SOT and DOT*
  - SOT
  - DOT
  - chromosphere in Ca II H and Hα

- *Hα ubiquity from sluggish recombination*
  - fast ionization in shocks, slow post-shock recombination
  - H I $n = 2$ population departure $\approx$ H II population departure
  - cool-gas Hα opacity $\ggg$ LTE opacity

- *DOT–SOT research*
  - profile-sampled Hα movies
  - Ba II 4554 dopplergram and magnetogram movies?
  - todo: comparison Hα – coronal diagnostics

HINODE MISSION STATEMENT

The primary goal of the Solar-B mission is to advance our understanding of the origin of the outer solar atmosphere, the corona, and of the coupling between the fine magnetic structure at the photosphere and the dynamic processes occurring in the corona.

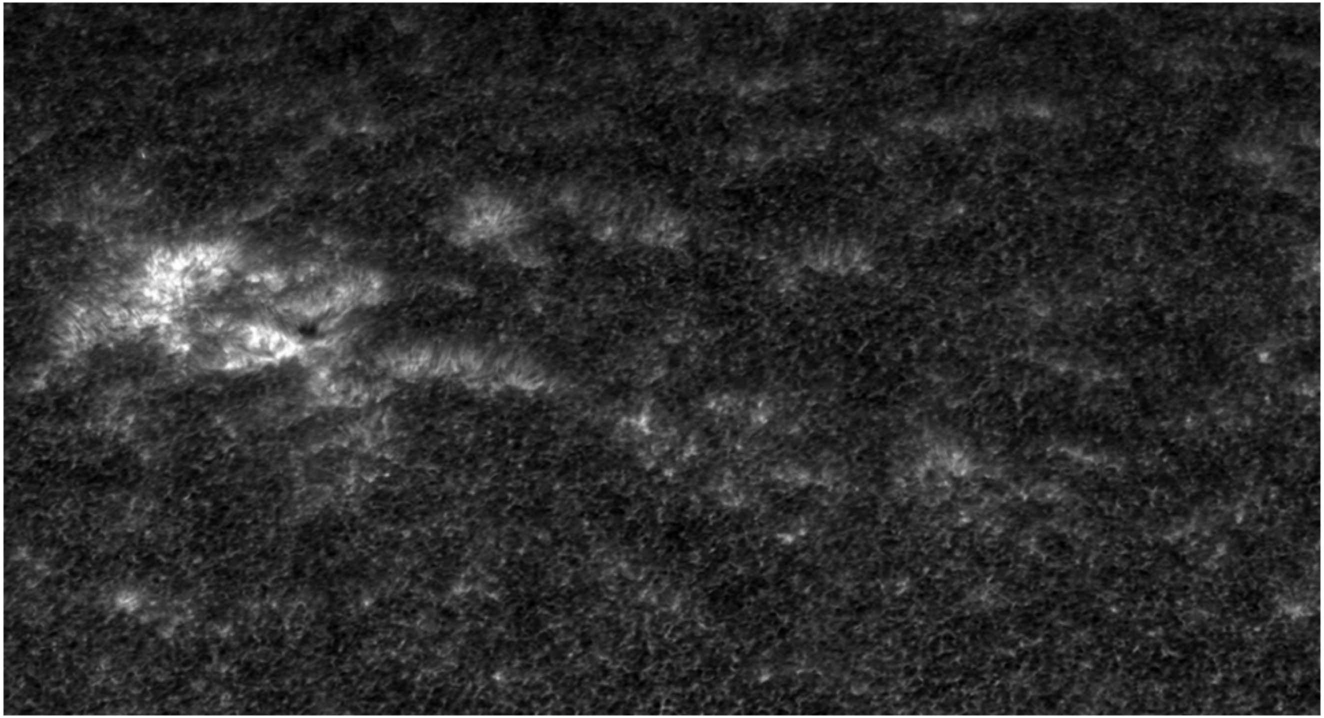


DUTCH OPEN TELESCOPE

http://dot.astro.uu.nl

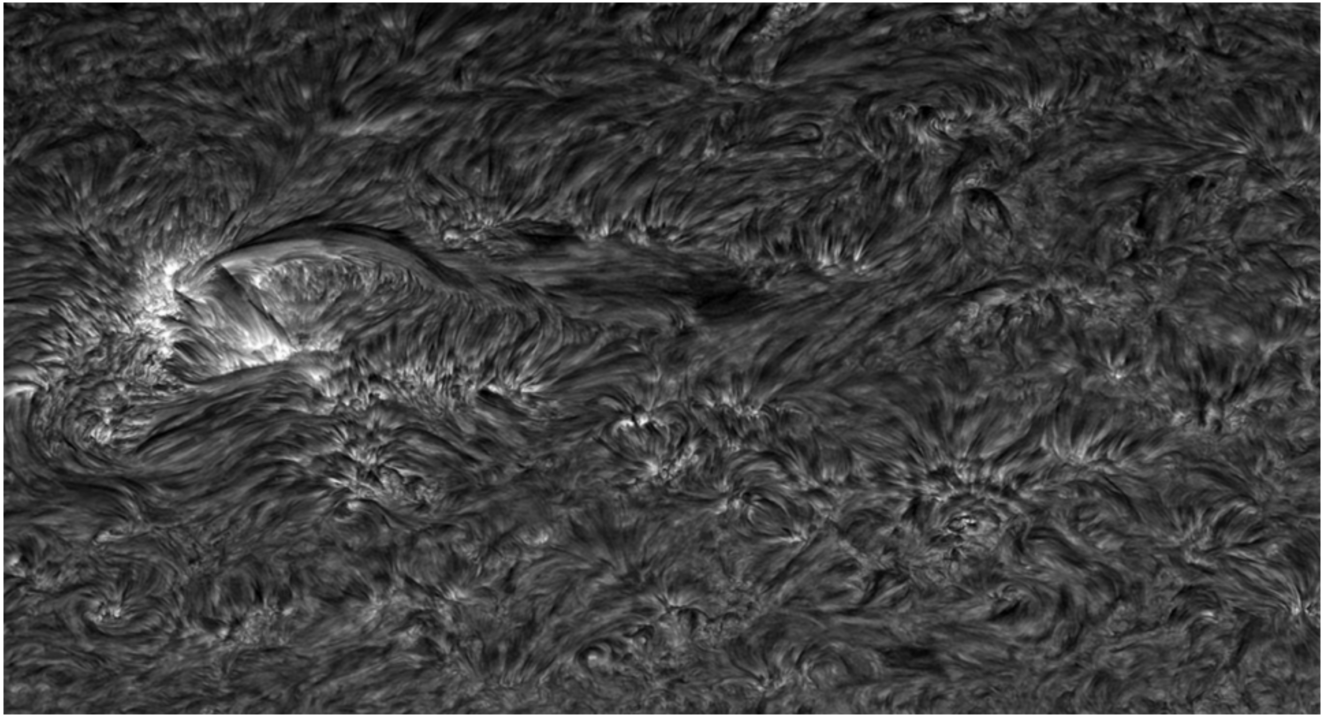
- *open principle*
  - wind-swept ocean site south of jet streams
  - wind-flushed but stable tower and telescope
  - fast on-site speckle reconstruction
- *synchronous movie maker*
  - continua, G band, tunable Ca II H, profile-sampled Hα
  - Ba II 4554 Doppler & Stokes-V with Irkutsk Lyot?
  - 0.2-0.3$''$ resolution when $r_0 > 8$ cm
- *future*
  - Utrecht University funding ends 1–1–2008
  - profile-sampled Hα = Hinode complementarity
  - plan: keep open, but no service-mode operation

Ca II H chromosphere



http://dot.astro.uu.nl/movies/2003-06-18-mu034-ca-core.mpg

Hα CHROMOSPHERE



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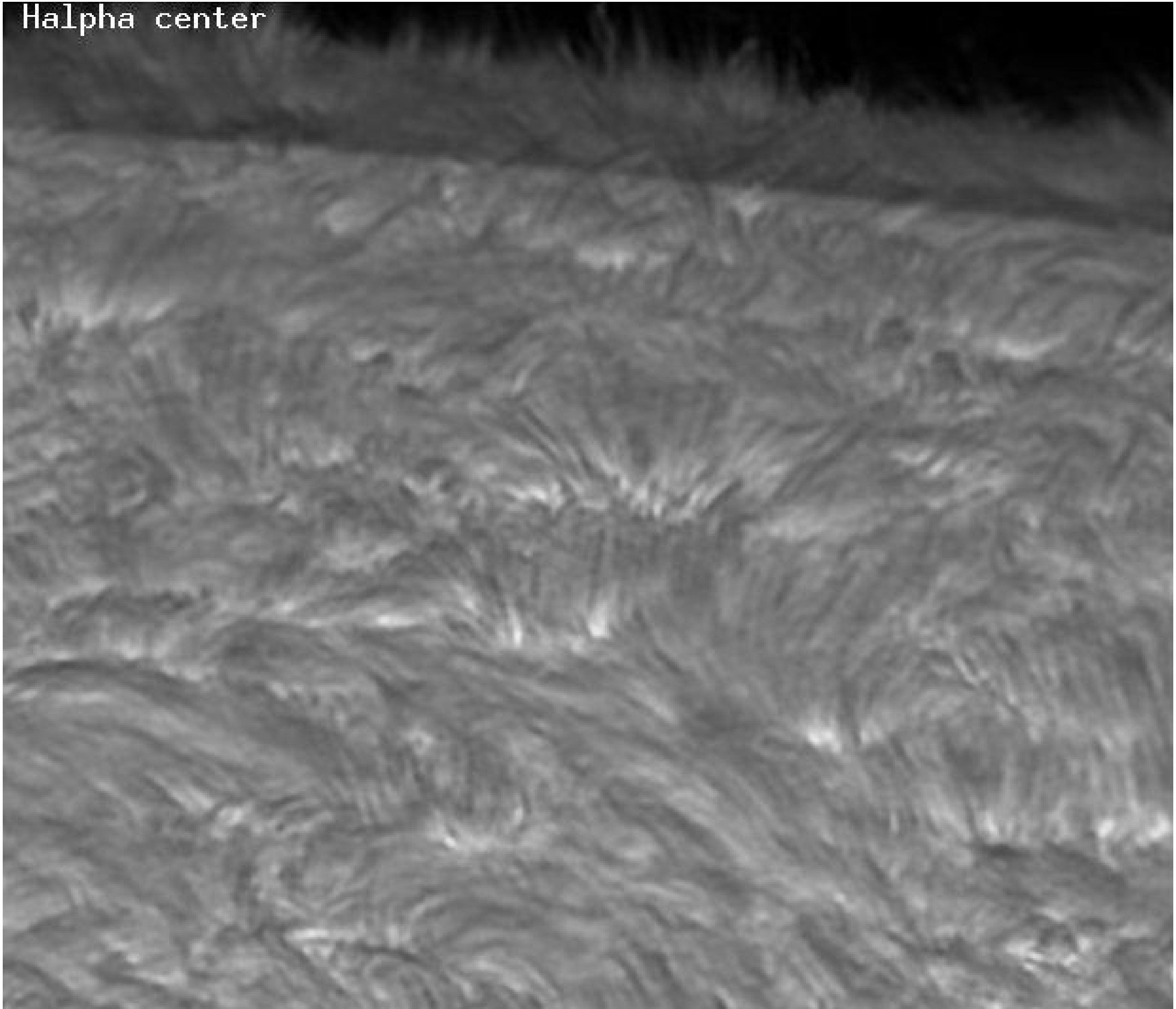
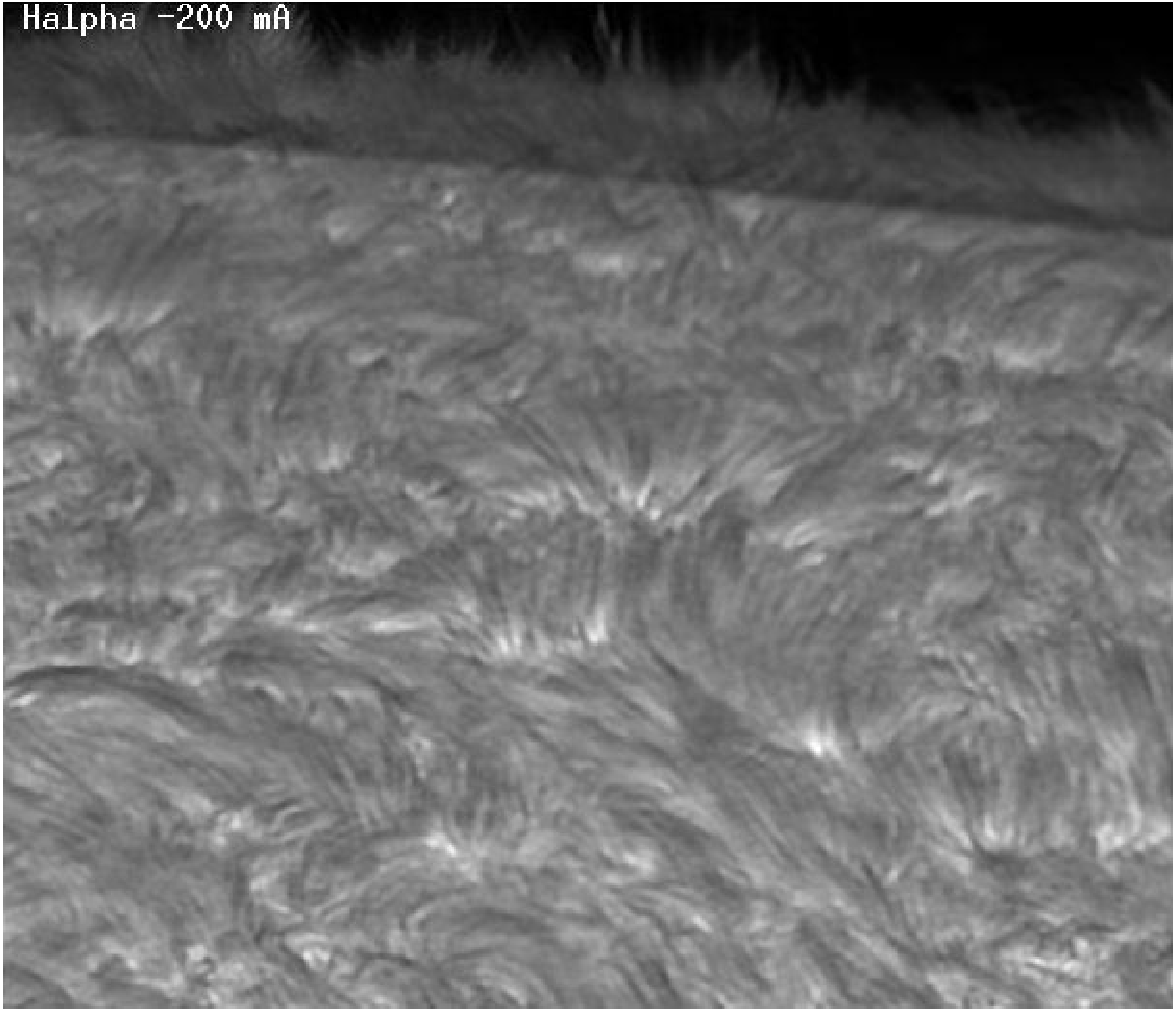
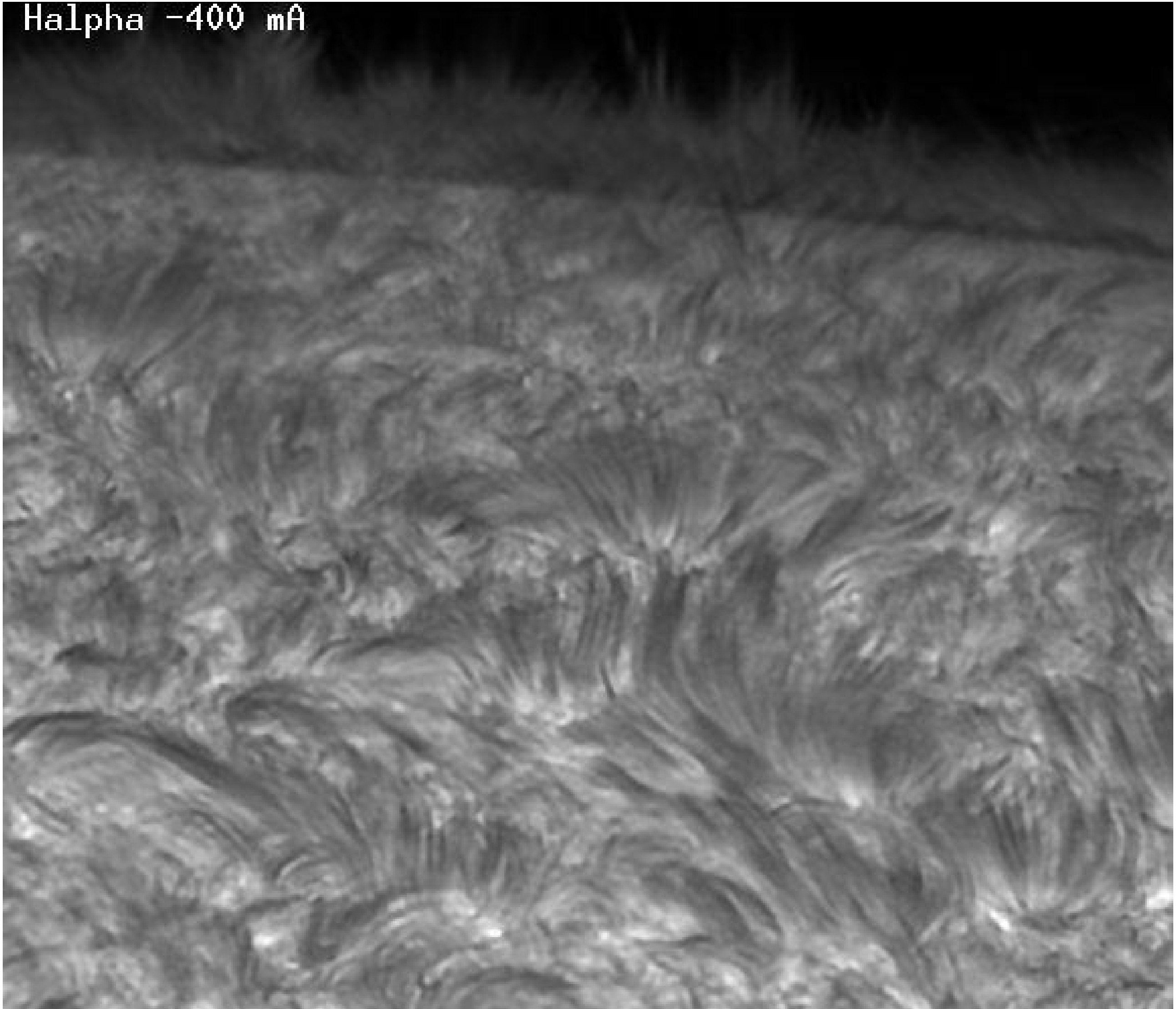
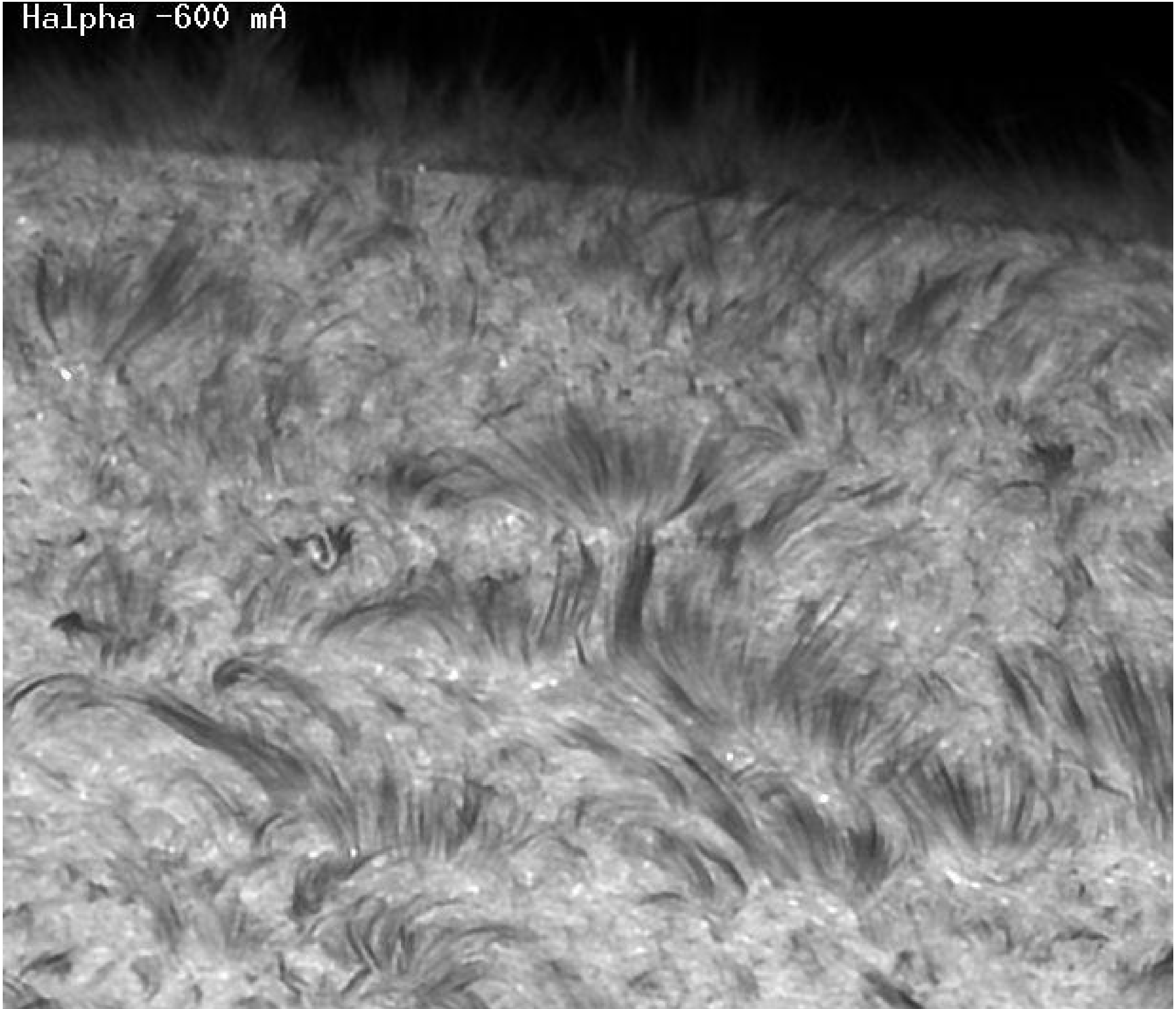

Halpha center


Halpha -200 mA


Halpha -400 mA


Halpha -600 mA


Halpha -800 mA

Non-equilibrium hydrogen ionization in 2D simulations of the solar atmosphere.

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ABSTRACT

Context. The ionization of hydrogen in the solar chromosphere and transition region does not obey LTE or instantaneous statistical equilibrium because the timescale is long compared with important hydrodynamical timescales, especially of magneto-acoustic shocks. Since the pressure, temperature, and electron density depend sensitively on hydrogen ionization, numerical simulation of the solar atmosphere requires non-equilibrium treatment of all pertinent hydrogen transitions. The same holds for any diagnostic application employing hydrogen lines.
Aims. To demonstrate the importance and to quantify the effects of non-equilibrium hydrogen ionization, both on the dynamical structure of the solar atmosphere and on hydrogen line formation, in particular Hα.
Methods. We implement an algorithm to compute non-equilibrium hydrogen ionization and its coupling into the MHD equations within an existing radiation MHD code, and perform a two-dimensional simulation of the solar atmosphere from the convection zone to the corona.
Results. Analysis of the simulation results and comparison to a companion simulation assuming LTE shows that: a) Non-equilibrium computation delivers much smaller variations of the chromospheric hydrogen ionization than for LTE. The ionization is smaller within shocks but subsequently remains high in the cool intershock phases. As a result, the chromospheric temperature variations are much larger than for LTE because in non-equilibrium, hydrogen ionization is a less effective internal energy buffer. The actual shock temperatures are therefore higher and the intershock temperatures lower. b) The chromospheric populations of the hydrogen $n = 2$ level, which governs the opacity of Hα, are coupled to the ion populations. They are set by the high temperature in shocks and subsequently remain high in the cool intershock phases. c) The temperature structure and the hydrogen level populations differ much between the chromosphere above photospheric magnetic elements and above quiet internetwork. d) The hydrogen $n = 2$ population and column density are persistently high in dynamic fibrils, suggesting that these obtain their visibility from being optically thick in Hα also at low temperature.

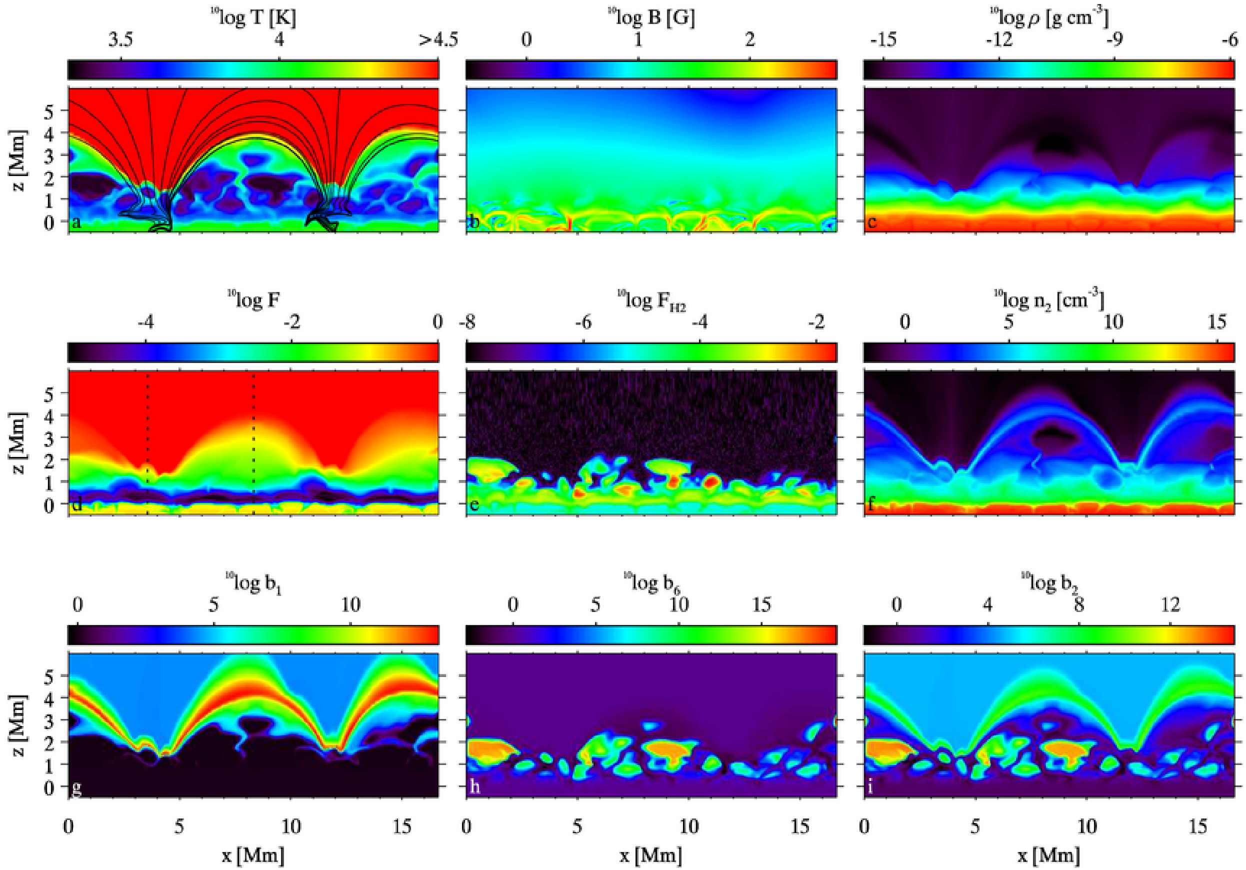


Fig. 1. Snapshot cutouts from the simulation, showing various quantities in a vertical plane after 8.5 minutes of solar-time evolution. Panel a: gas temperature, with magnetic field lines that extend into the corona overplotted in black; b: magnetic field strength; c: mass density d: non-equilibrium ionization degree of hydrogen; e: fraction of hydrogen atoms in the form of H_2 molecules; f: hydrogen n = 2 level population; g: departure coefficient for the hydrogen n = 1 level population; h: departure coefficient for the hydrogen n = 6 level population; i: departure coefficient for the hydrogen n=2 level population. The columns used in Figs. 2 and 3 are indicated by dotted lines in panel d.

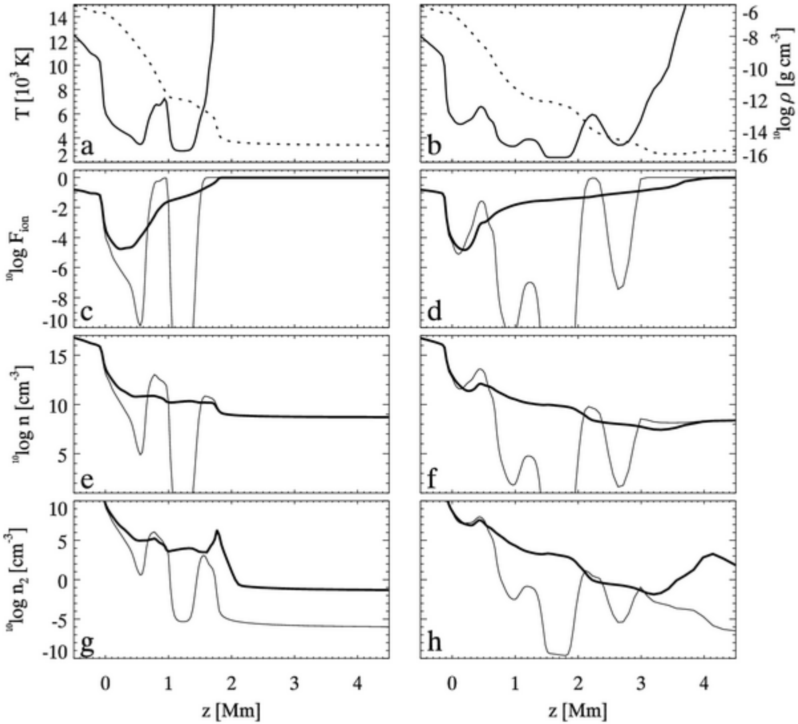
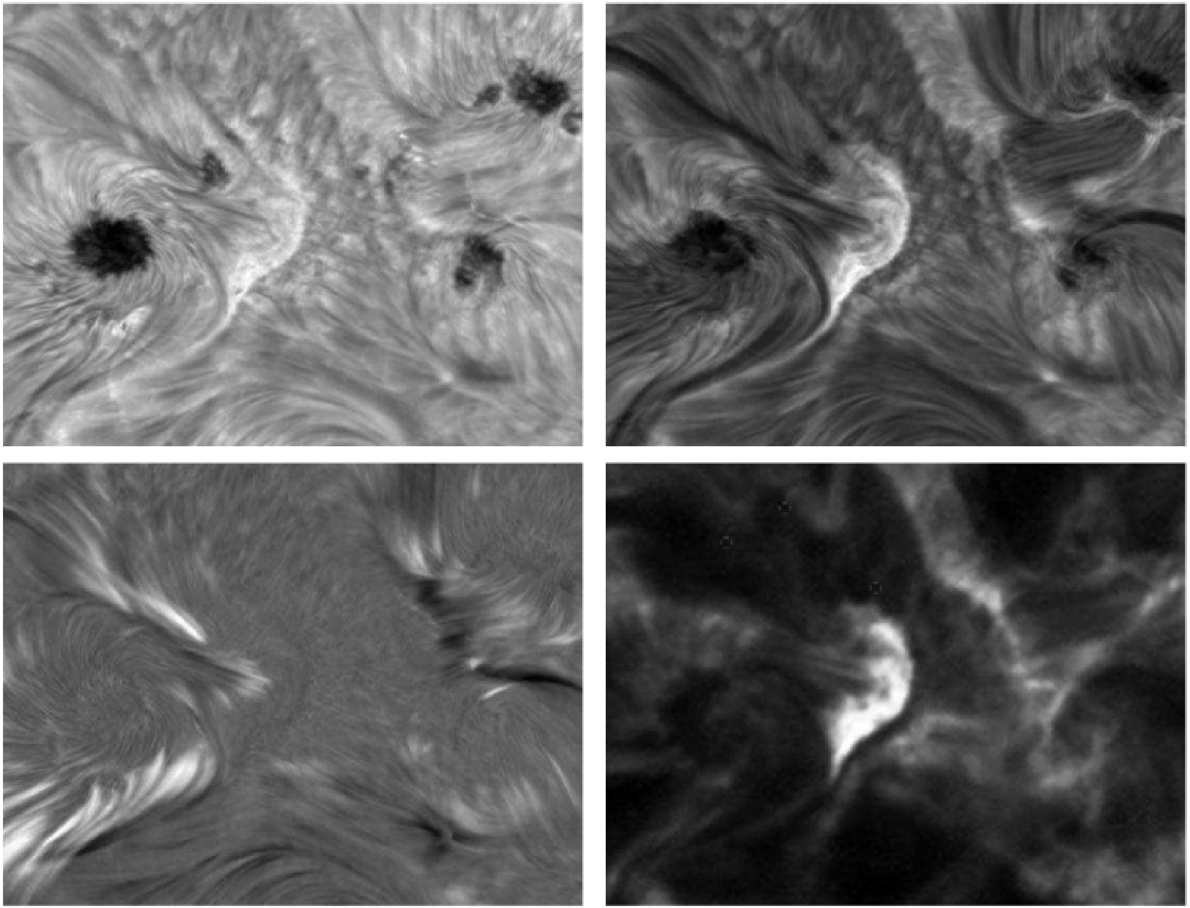


Fig. 2. Properties of the simulation along a column in a magnetic element (left-hand column) and in the internetwork (right-hand column). The red curves result when assuming LTE for these stratifications. Panels a and b: temperature (solid) and mass density (dashed, right-hand scale); c and d: non-equilibrium (thick) and LTE ionization degree (thin); e and f: non-equilibrium (thick) and LTE proton density (thin); g and h: population of the $n = 2$ level for the non-equilibrium (thick) and LTE (thin) case.

DOT – SOT RESEARCH



http://dot.astro.uu.nl/movies/2005-07-09-AR10786-gb-hac-had-171.mpg