UK-Germany National Astronomy Meeting

SP5: Waves in the solar atmosphere, March 27, 2012

Revealing the nature of magnetic shadows of network magnetic elements with numerical 3D-MHD simulations.

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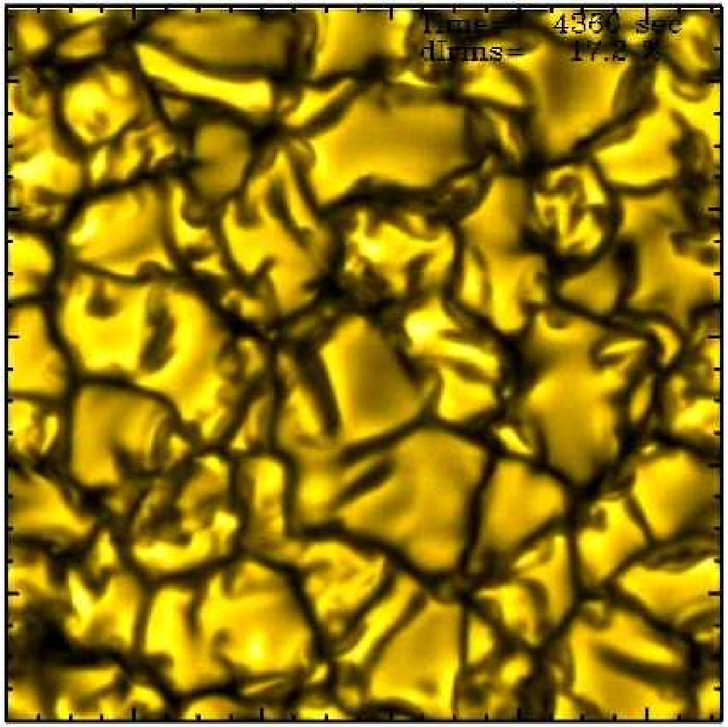
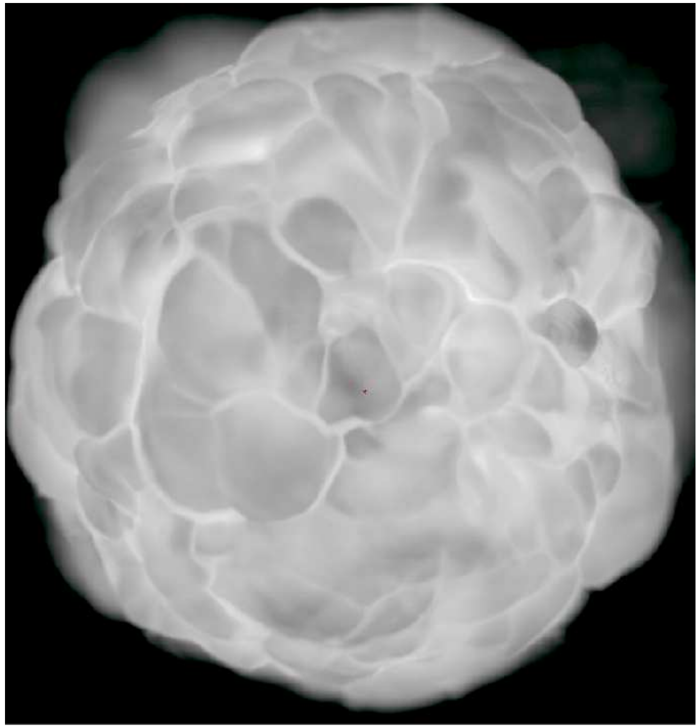
1. Numerical simulations of wave propagation in the near surface layers of the Sun



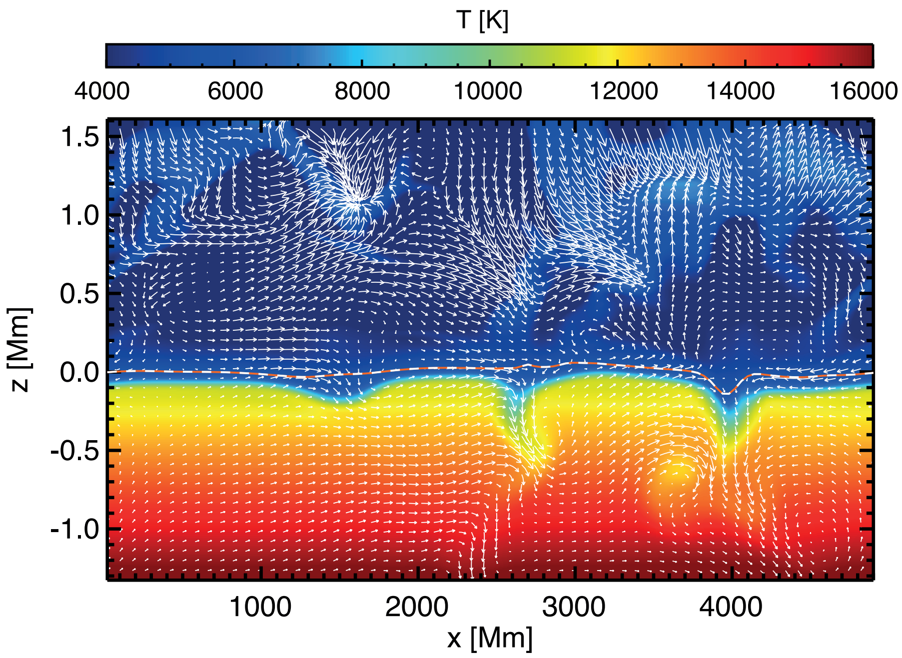
Simulation of *solar granulation with CO^{5}BOLD*.
$400 \times 400 \times 165$ grid cells, 11.2×11.2 Mm,
Mean contrast at $\lambda \approx 620$ nm is 16.65%.
Courtesy *M. Steffen, AIP*

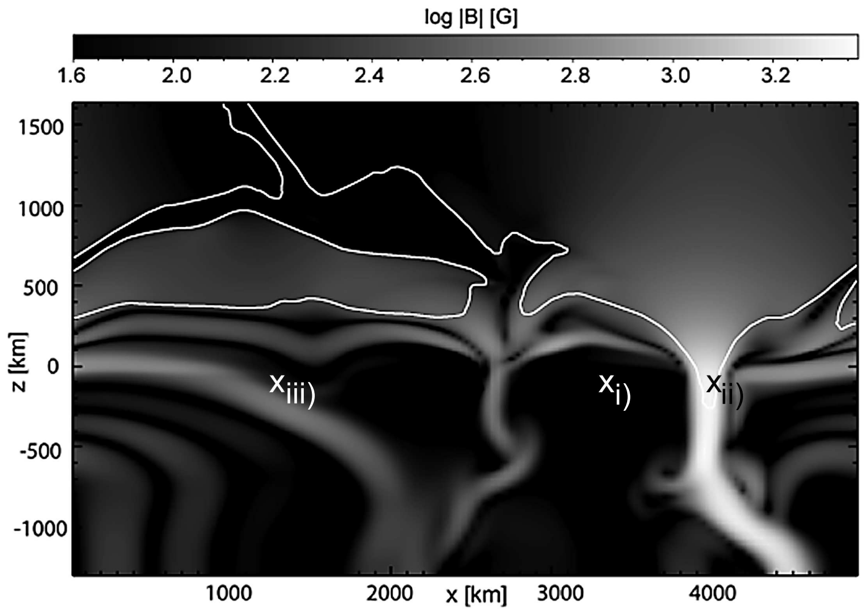


Simulation of a *red supergiant with CO^{5}BOLD*.
235^3 grid cells, $m_{\rm star} = 12 m_\odot$,
$T_{\rm eff} = 3436$ K, $R_{\rm star} = 875 R_\odot$
Courtesy *Bernd Freytag*

More on the CO^{5}BOLD code in *Freytag et al.: 2012, J. Comput Phys. 231, 919*

1. Numerical simulations of wave propagation (cont.)





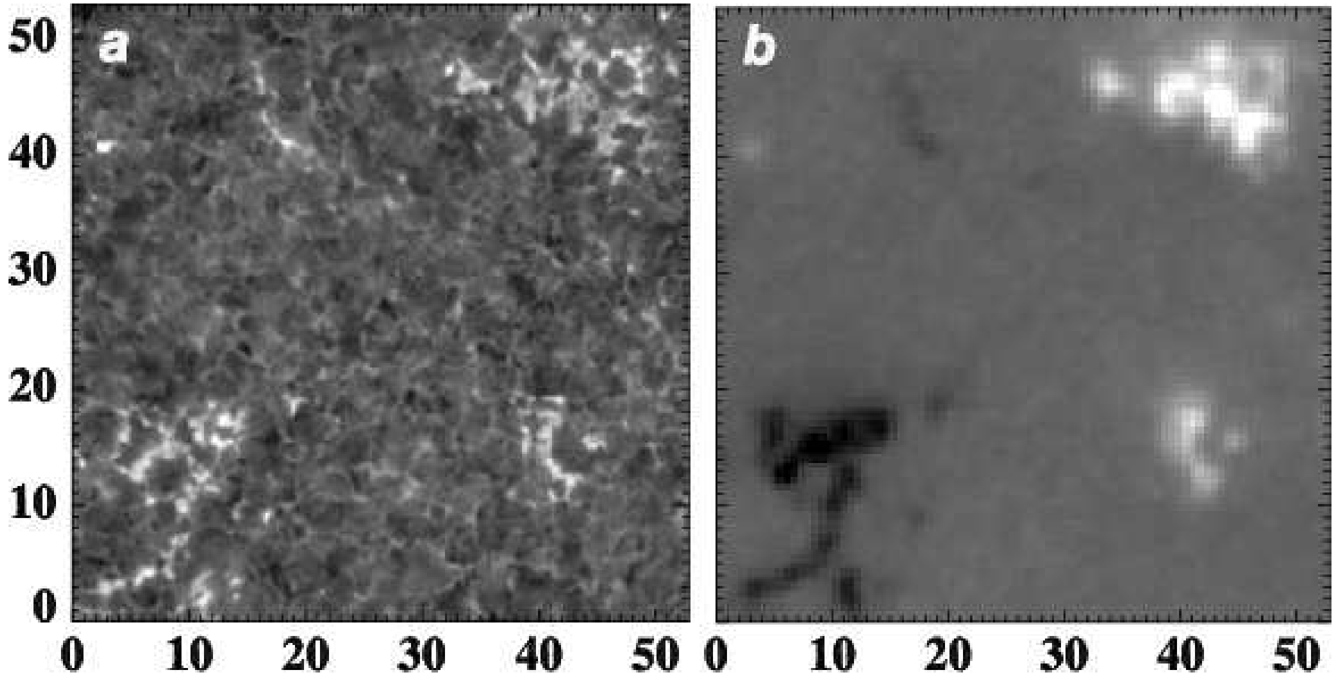
Temperature (colors), velocity (arrows), and optical depth $\tau_c = 1$ (dashed curve).

Magnetic field strength (gray scales), level where $c_s = c_A$ (white contour), locations of local wave excitation (crosses).

Movies of wave excitation at $\times_{\mathrm{i}}$, $\times_{\mathrm{ii}}$, $\times_{\mathrm{iii}}$, and along the lower boundary.

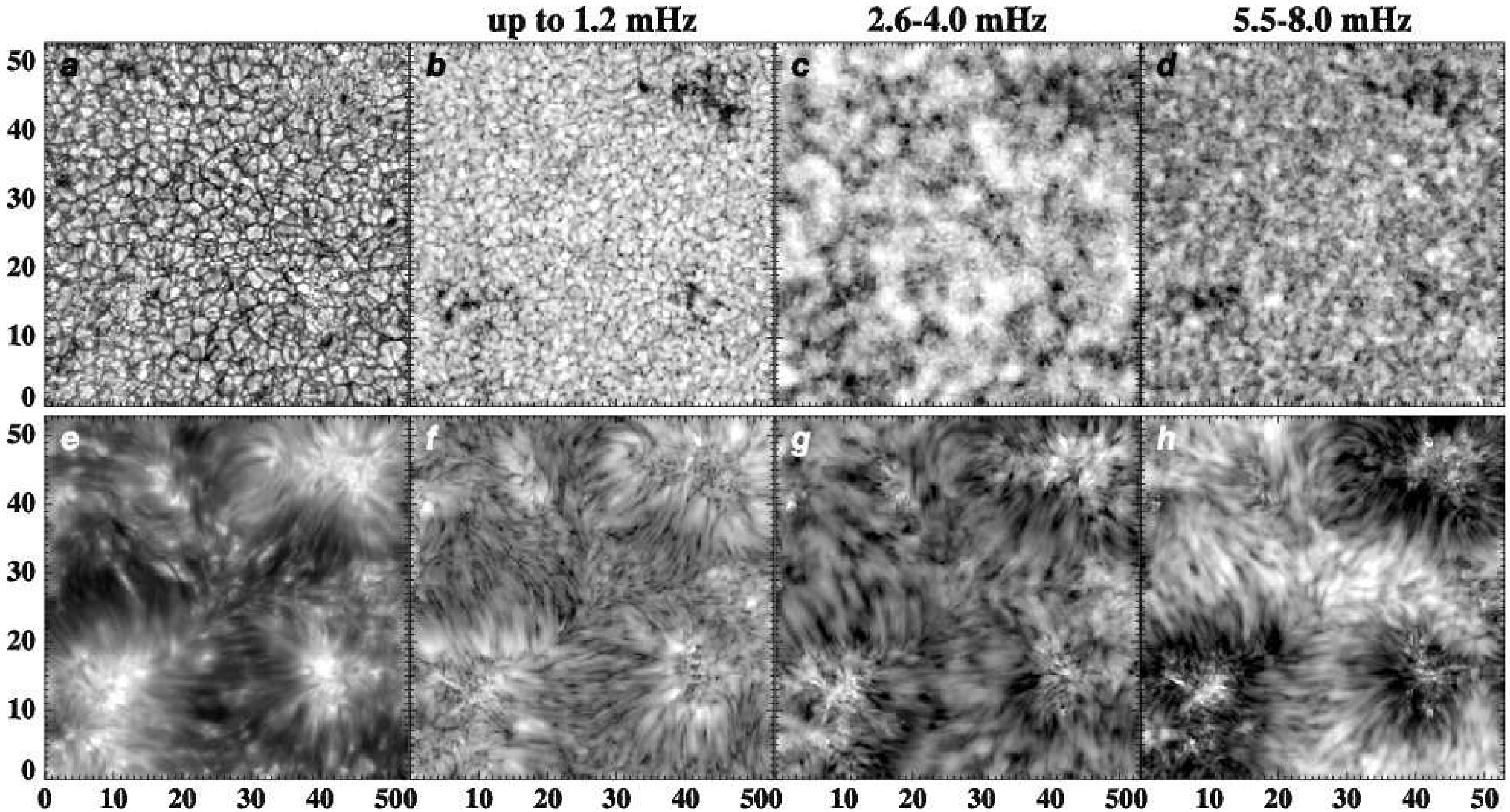
2. The magnetic shadow

Magnetic shadow first described by *Judge, Tarbell & Wilhelm (2001), ApJ 554, 424* and *McIntosh & Judge (2001), ApJ 561, 420*.



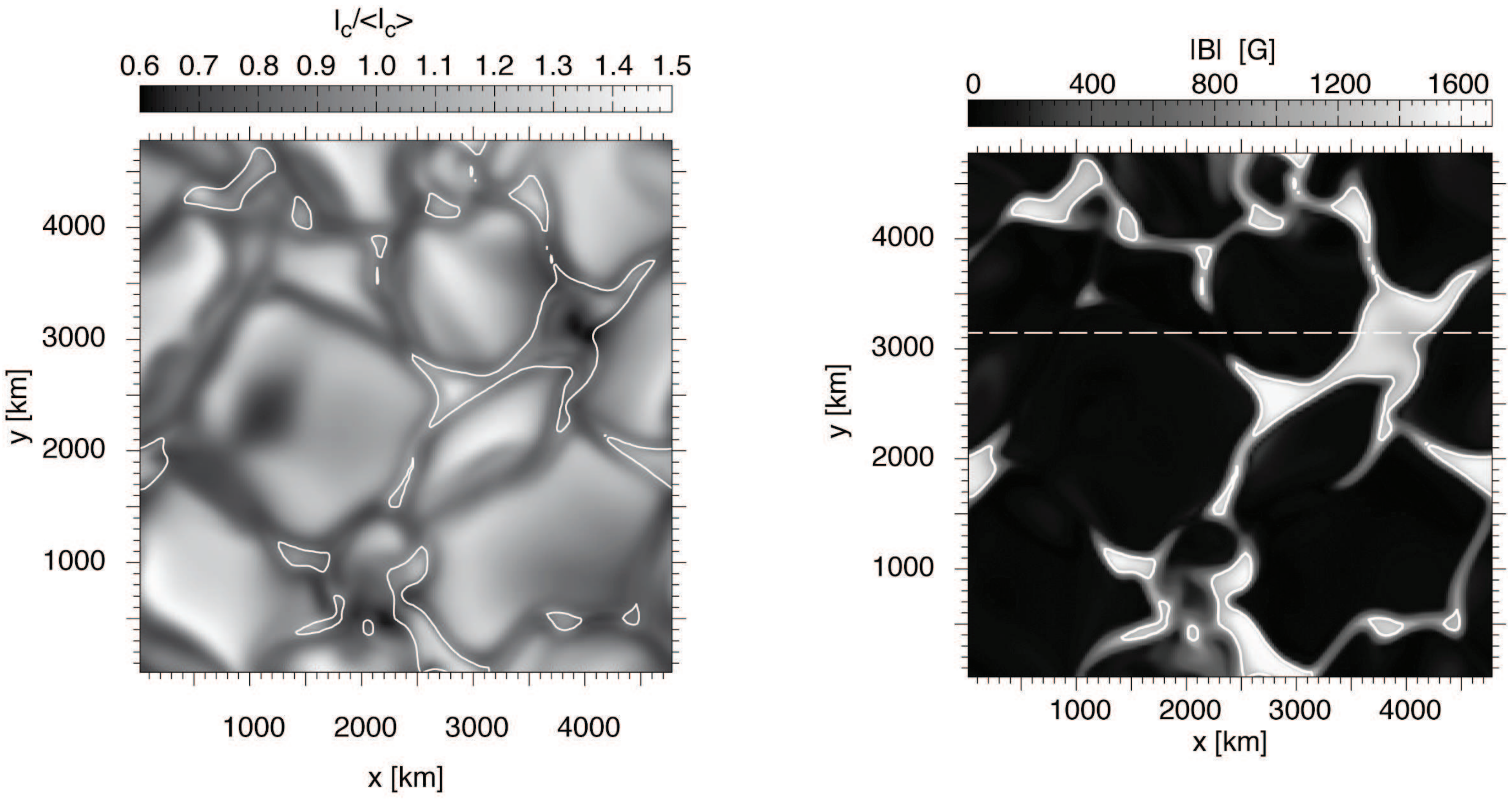
FOV of $53'' \times 53''$. *Left:* intensity at $\Delta\lambda = 0.16$ nm from Ca II 854.2 line center, showing individual elements of magnetic network patches. *Right:* Corresponding high res. MDI magnetogram. From *Vecchio, Cauzzi, Reardon et al. (2007), A&A 461, L1.*

2. The magnetic shadow (cont.)



a) Broadband continuum at 710 nm. *e)* Line core intensity of CaII 854.2 nm. *b)–d)* and *f)–h)* Logarithm of the Fourier Doppler-velocity power averaged over the indicated range of frequencies of the photospheric line Fe I 709.0 nm *(b)–d))* and the chromospheric line Ca II 854.2 nm *(b)–d))*. From *Vecchio, Cauzzi, Reardon et al. (2007), A&A 461, L1.* obtained with IBIS at DST.

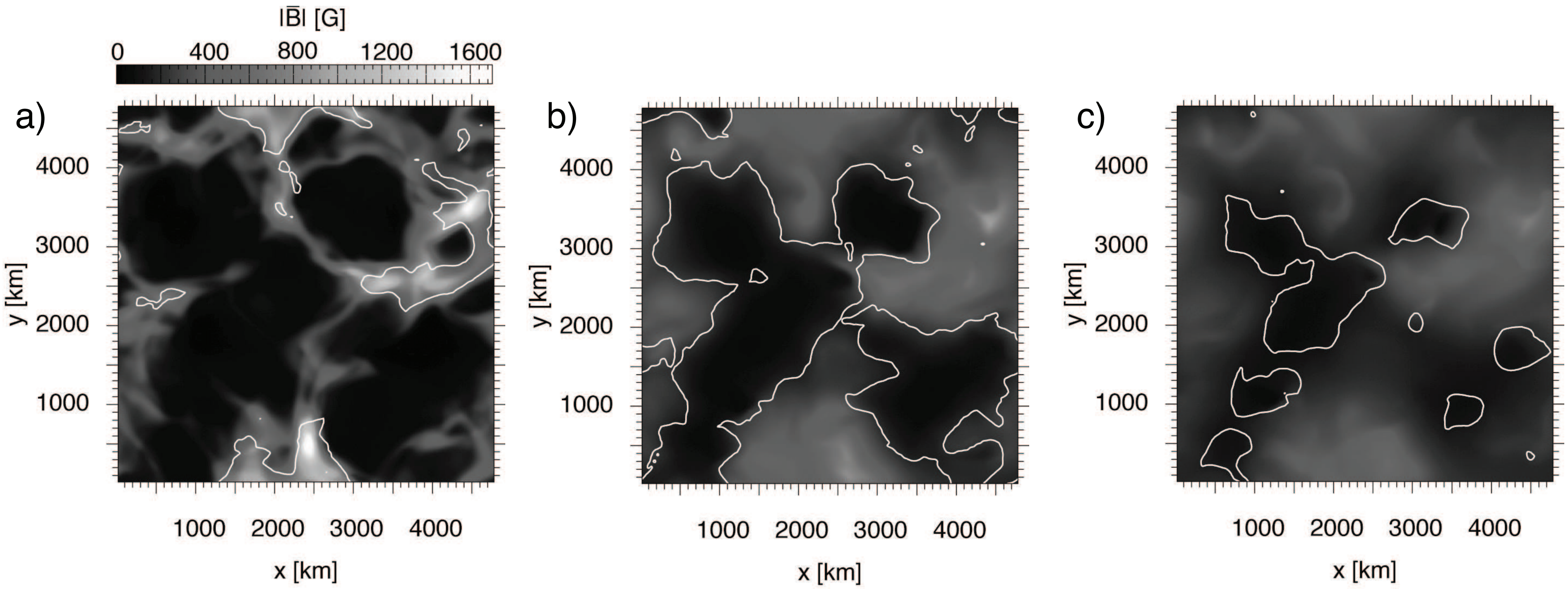
3. Numerical simulation of the magnetic shadow



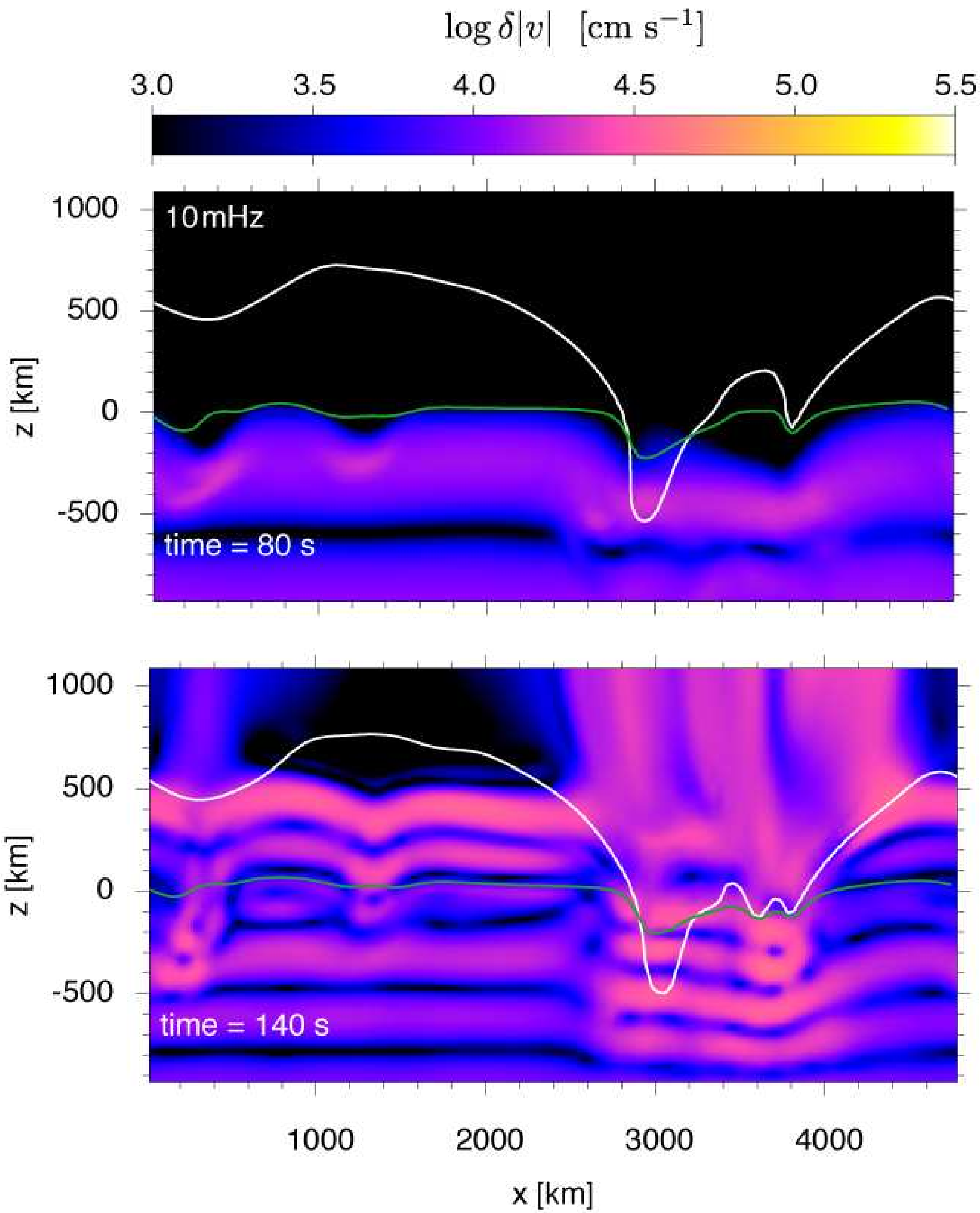
Left: FOV of $6.6'' \times 6.6''$ in white light. *Right:* Magnetic field strength at $\langle \tau_c \rangle = 1$.

Contours: Equipartition level where $c_s = c_A$.

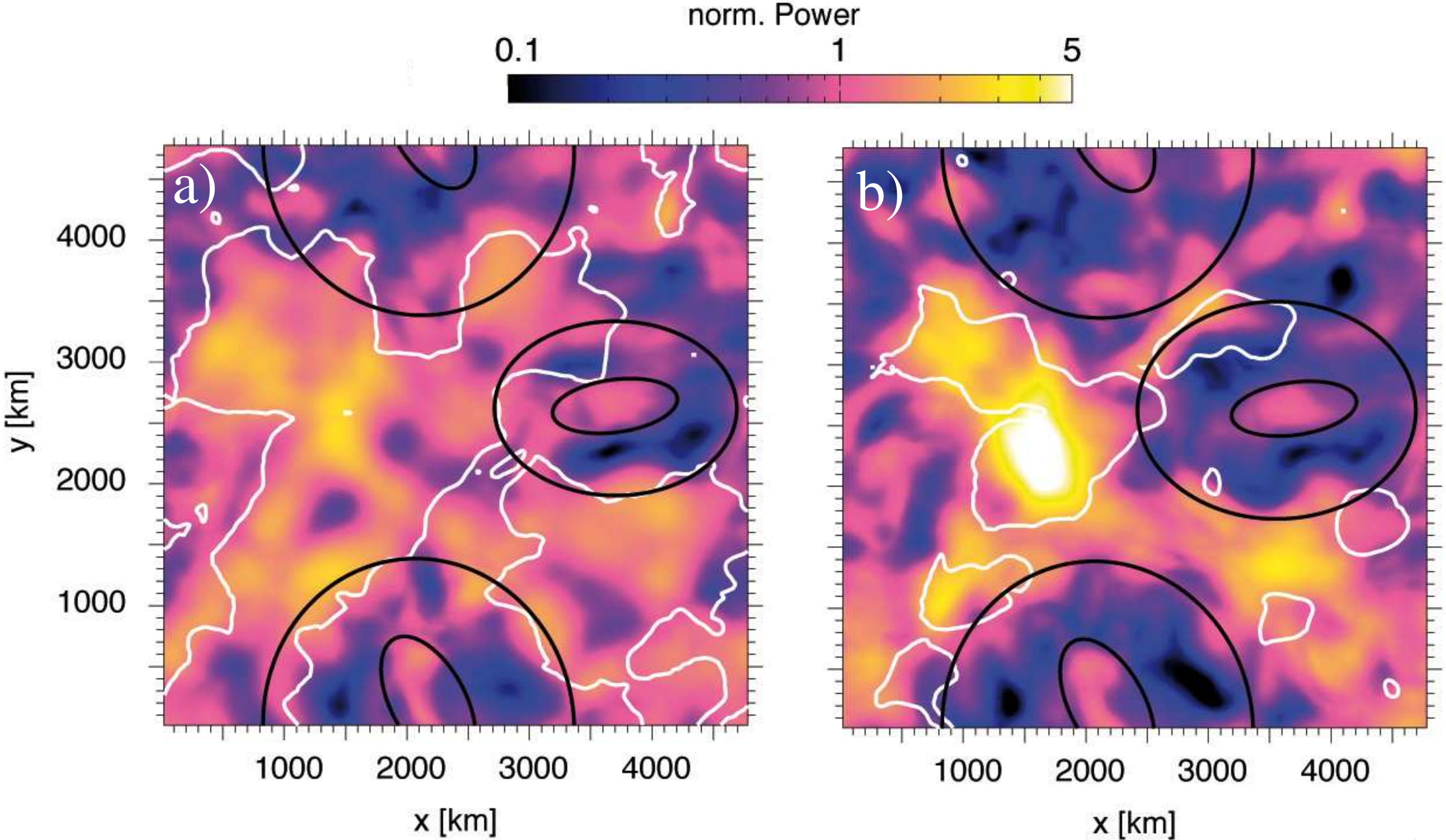
3. Numerical simulations of wave propagation (cont.)



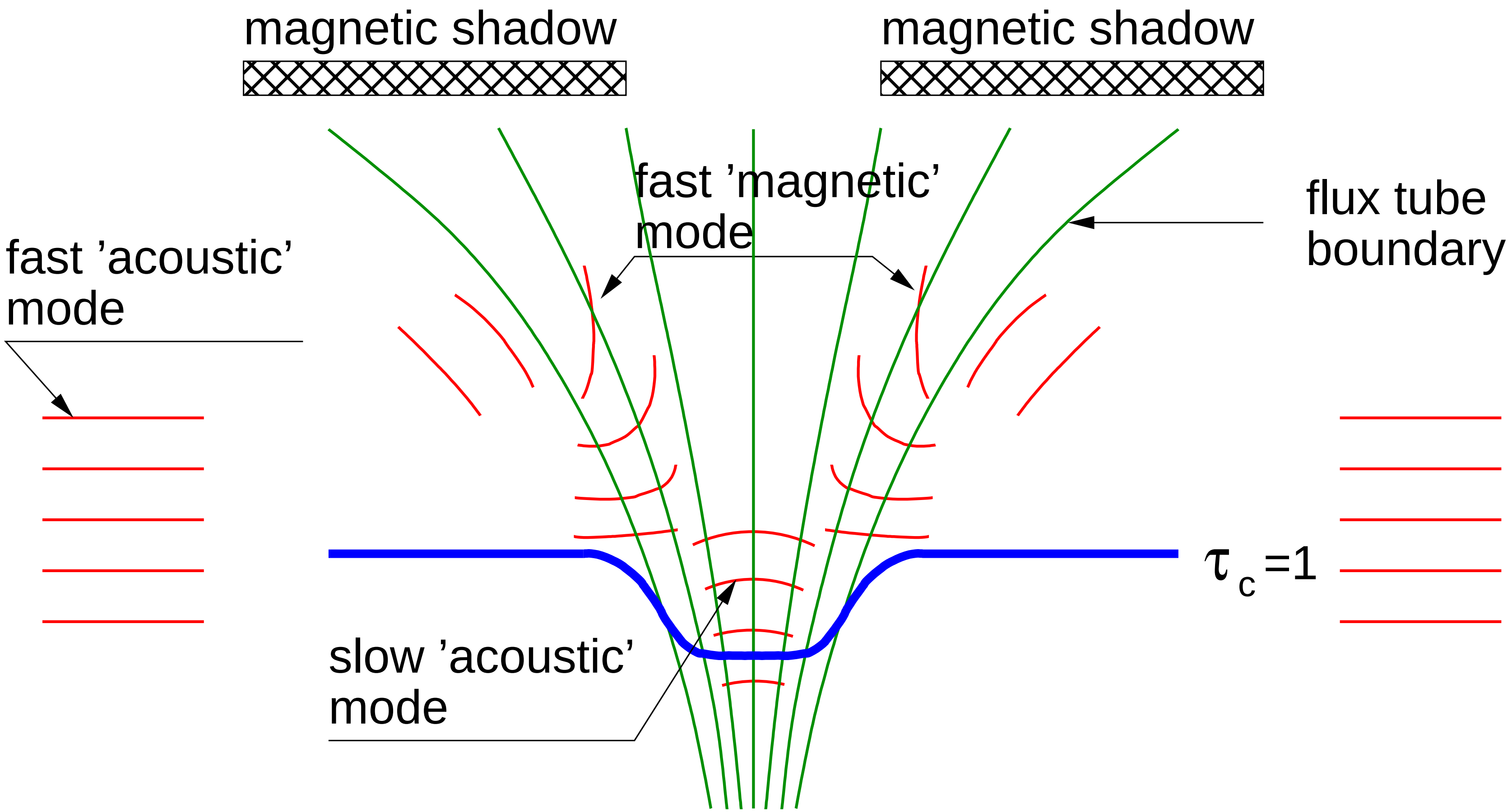
Magnetic field strength, $|B|$, averaged over $\Delta t = 1250$ s at the optical depth levels of *a)* $\tau = 1$, *b)* $\tau = 8 \cdot 10^{-4}$, *c)* $\tau = 6.7 \cdot 10^{-5}$, corresponding to approximately $z = 0$, 400 km, and 600 km above $\langle\tau\rangle = 1$ respectively. *Contours:* Equipartition level where $c_s = c_A$.



Two time instances of the wave-propagation showing the logarithm of the absolute velocity perturbation, $\log \delta|v|$. *Green contour:* Optical depth $\tau_c = 1$. *White contour:* Equipartition level $c_s = c_A$.



Power maps of the vertical velocity perturbations, δv_z, taken at *a)* $\tau_c = 8 \cdot 10^{-4}$ and *b)* $\tau_c = 6.7 \cdot 10^{-5}$. The *white contours* shows the equipartition level $c_s = c_A$. The *ellipses* mark regions where the *magnetic shadow* can be identified. Note suppression of power in the region between the large and the small ellipses.



Sketch of the three different magneto-acoustic modes which lead to the phenomenon of the magnetic shadow.

Table of content

References

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