MAGNETOACOUSTIC WAVES PROPAGATING ALONG A DENSE SLAB AND HARRIS CURRENT SHEET AND THEIR WAVELET SPECTRA

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There is a common endeavor to detect magnetoacoustic waves in solar flares. Our study contributes to this topic using an approach of numerical simulations (Fig.1). We studied a spatial (Figs. 2) and temporal (Fig.3) evolution of impulsively generated fast and slow magnetoacoustic waves propagating along the density slab and Harris current sheet using 2D magnetohydrodynamic numerical models. Wave signals computed in numerical models were used for computations of the temporal (Fig.3) and spatial (Fig.4) wavelet spectra for their possible comparison with those obtained from observations.

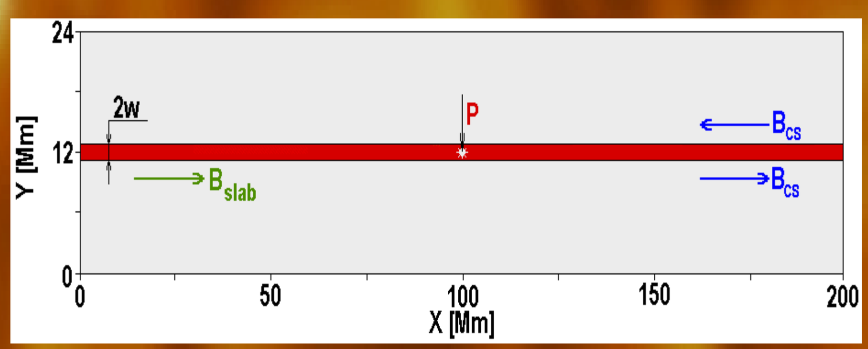


Fig.1:
Scheme of a 2D numerical box with a waveguide (in red) in its center.

The length X of the numerical box and waveguide is 200 Mm. The width Y of the numerical box is 24 Mm, and w indicates the half-width of the waveguide. The initial perturbation P is located in the center of the waveguide (X = 100 Mm). Arrows show the magnetic field orientation in the dense slab B_{slab} and in the Harris current sheet B_{cs}. For more details see [1].

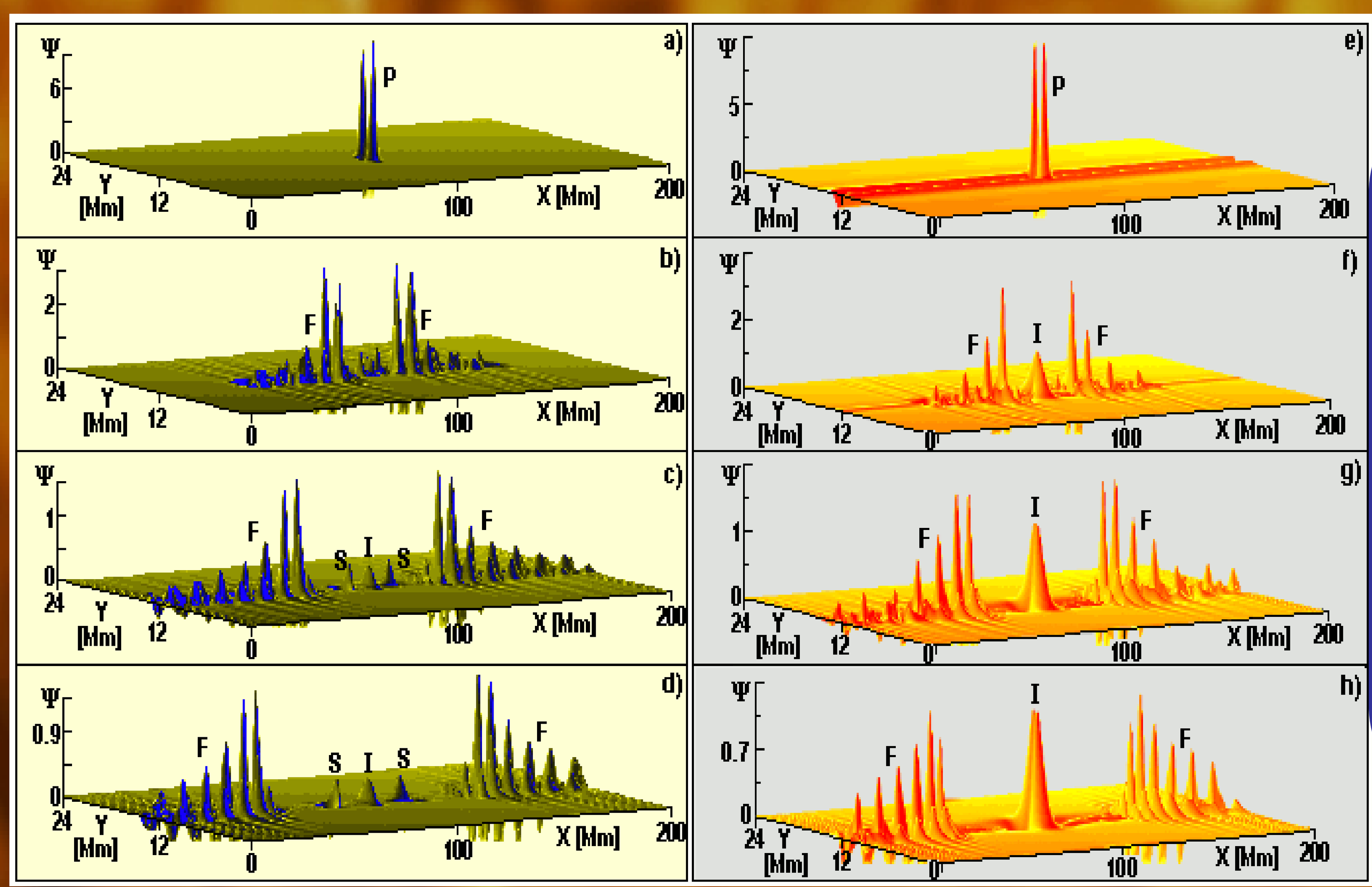


Fig.2:
Spatial evolution of the fast *F* and slow *S* magnetoacoustic waves

propagating in the dense slab (panels *a–d*) and the Harris current sheet (panels *e – h*) expressed as $\Psi = 10^{-3}\,(\rho - \rho_0) / \rho_0$, where ρ is the density and ρ_0 is the initial density.

In both cases, the waveguide half-width w is 1Mm. The initial perturbation P is generated in the center of waveguide (X = 100 Mm, Y = 12 Mm).

Panels in both columns show propagating waves at times 0.5 s (panels *a* and *e*), 50 s (panels *b* and *f*), 100 s (panels *c* and *g*), and 150 s (panels *d* and *h*) after their generation by the initial perturbation.

The peak *I* remains at the site of the initial perturbation. This stationary structure is known as the entropy mode (see [3]).

Fig.3:
Temporal evolution of the fast *F* magnetoacoustic waves

Time series of $\Psi = 10^{-3}\,(\rho - \rho_0) / \rho_0$ and their wavelet spectra in the dense slab (panels *A – C*) and Harris current sheet (panels *D – F*).

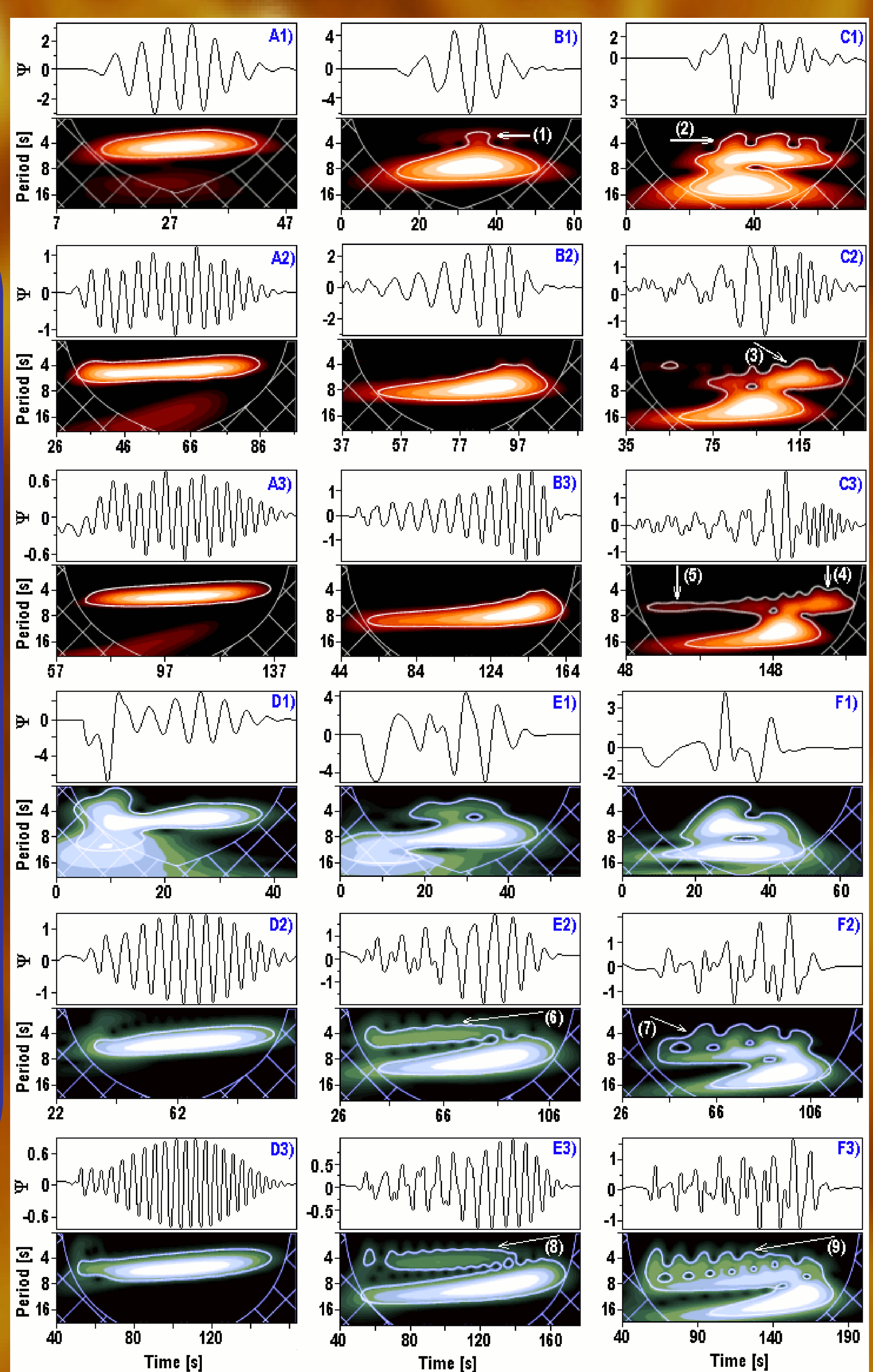
The wavelet spectra with the tadpole structures [4] depend on the half-width of the waveguide w and a distance d between the detection point and initial perturbation P:

w = 0.5 Mm (panels *A* and *D*),
w = 1.0 Mm (panels *B* and *E*),
w = 2.0 Mm (panels *C* and *F*).

d = 10 Mm (panels *A1– C1* and *D1 – F1*),
d = 30 Mm (panels *A2– C2* and *D2 – F2*),
d = 50 Mm (panels *A3– C3* and *D3 – F3*).

Some wavelet tadpole patterns show various types of additional structures (arrows 1 – 9).

For more details see [1].



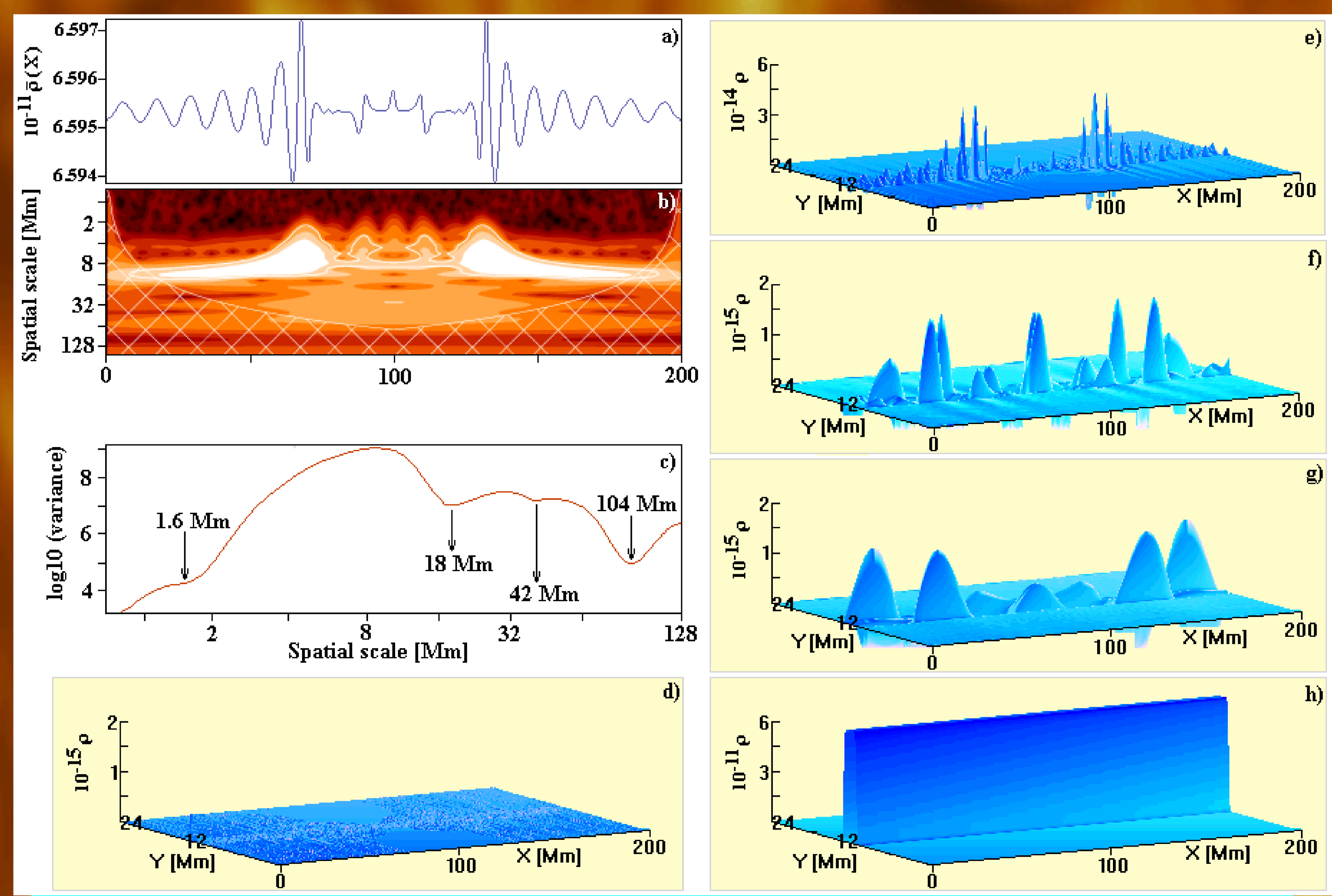


Fig.4: Separation of density variations according to their characteristic spatial scales.

Panel (a) shows variations of the averaged density $\rho(X)$ depending on the spatial coordinate X. Panel (b) shows the wavelet power spectrum of the variable $\rho(X)$. Panel (c) presents the global wavelet spectrum with individual minima at 1.6, 18, 42, and 104 Mm. Panel (d) shows the filtered spatial structure for spatial scales < 1.6 Mm corresponding to a numerical noise. Panel (e) presents the filtered spatial structure for spatial scales in the range of 1.6 – 18 Mm, showing both fast and slow magnetoacoustic waves. Panels (f) and (g) present filtered spatial structures with spatial scales in the ranges 18 – 42 and 42 – 104 Mm, respectively, showing long spatial components of the waves. Panel (h) presents the filtered spatial structure with spatial scales > 104 Mm, showing the original density profile (for more details see [1] and [2]).

CONCLUSIONS:

Temporal and spatial wavelet spectra of the propagating fast magnetoacoustic waves allow us to estimate basic parameters of waveguides and perturbations. It was shown that the wavelet spectra of waves in the density slab and current sheet differ in additional wavelet components which appear in association with the main tadpole structure. While in the density slab this additional component is always delayed after the tadpole head, in the current sheet this component always precedes the tadpole head. It could help to distinguish a type of the waveguide in observed data. We present a technique based on wavelets, which separates wave structures according to their spatial scales [2]. This technique shows not only how to separate the magnetoacoustic waves and waveguide structure in observed data, where the waveguide structure is not known, but also shows how propagating magnetoacoustic waves would appear in observations with limited spatial resolutions. Possibilities of a detection of these waves in observed data are mentioned in [1].

REFERENCE:

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