Cosmic Magnetic Fields:
From Planets, to Stars and Galaxies
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3D reconstruction of solar magnetoacoustic waves

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Abstract. Using a new multi-wavelength technique applied on the solar corona SOHO/EIT images containing magnetoacoustic waves (EIT waves), we constrain the wave phase velocity and, as well, some β-model, height related considerations for the vertical extent of the wave, applied on the particular EIT wave triggered by the eruptive event from 15th of August, 2001.

Keywords. Sun: UV radiation – atmospheric motions – techniques: image processing – waves

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The method employed in this paper, described in Popescu & Mierla 2008, is extremely useful in determining the solar waves phase velocity, here being applied on the eruptive event from 15th of August 2001 seen by the SOHO/EIT instrument (Delaboudinière *et al.* 1995). The EIT instrument aboard SOHO observes the Sun in four different wavelengths, namely 171 Å (Fe IX/Fe X; 1.3×10^6 K), 195 Å (Fe XII; 1.6×10^6 K), 284 Å (Fe XV; 2.0×10^6 K) and 304 Å (He II; 8.0×10^4 K), and, in consequence, from high chromosphere to mid-corona.

It has been proved by Gary (2001) that the plasma β-model plays an important role in the solar corona properties and phenomena, especially in dealing with the use of force-free magnetic fields in extrapolation over the entire coronal field range, without assuming $\beta \ll 1$ in order to overcome the full boundary conditions nonexistence in the two $\beta > 1$ regions. Comparing the Gary (2001) plasma model representation as function of height with our results, it can be observed that for the high chromosphere's 304 Å wavelength, due to a wider β allowance, we will have a greater velocity dispersion in the phase space, from where a larger number of lines in the corresponding FFT maps associated to a large number of frozen in the field plasma movements. As the height increases, with the increase of temperature in the mid-corona, from 171 Å, to 195 Å and, finally 284 Å, we have a decrease in the velocity map lines number, consistent with the narrowing of the β (where $\beta < 1$) allowed region (Gary 2001).

Without counting the central zero point line, the first and the fifth line corresponds to the velocity of the EIT wave, the second and the fourth to the velocity projection into the image plane of the CME, and the third, to the horizontal inter-shock plasma motions (see the FFT velocity map from Popescu & Mierla 2008). By comparing the evolution of the same velocity line for different wavelengths, we remark that the velocity of the phenomena giving these lines increases with height. In the case of the propagating wave, the crest is moving faster than the leading edge, this causing a steepening of the front portion of the wave and the formation of a steady shock wave in which the dissipative effects equilibrate the convective steepening effects. Into the SOHO/EIT images the dissipative effects can be identified as luminous features on the crest of the two wavefronts. This steepening is consistent with the behavior of a compression wave described by Priest (1987), and even more, with a *fast* magnetoacoustic wave, the magnetic field before the wavefronts intensifying and being seen as "dimming" regions propagating in front of the shocks.

In the FFT maps, for the lines to the left of zero, the velocity radically increases with height, while the ones to its right present just a slight increase. The reason for this behavior will be found by returning to the EIT images where we observe that one side of the wavefront is bouncing into the active region 09775, being decelerated. With the height increase, the magnetic field lines over this active region cover a wider region in the corona, rotating, as the fast shock passes, away from the shock normal (Priest 1987) and forcing the EIT and CME shock waves to adopt a larger tilt angle relative to the solar surface. On the other side, away from the active region, the EIT and CME propagation do not meet any resistance from the solar background. This difference between the two wavefronts gives rise to an excess of magnetic pressure that must relax by plasma movement from high to low pressure regions. This movement can be seen into the EIT images as arcades uniting the two EIT wavefronts, and moving away from the mentioned active region. For the 15th of August 2001 EIT wave, the velocity line close by the central zero point (the zero velocity) represents the velocity of the inter-wavefronts flows described above.

In the transition zone between the chromosphere and corona (Athay *et al.* 1980; Malherbe & Priest 1983) the horizontal flows in the proximity of a prominence are usually between 5 and 20 km/s. Scaling the velocity in all the maps with the velocity of the inter-wavefronts flow for 284 Å, considered to be 20 km/s, and translating the wavelength into the corresponding plasma temperature, we can actually follow the extent of the waves into the solar atmosphere as represented into Figure 1.

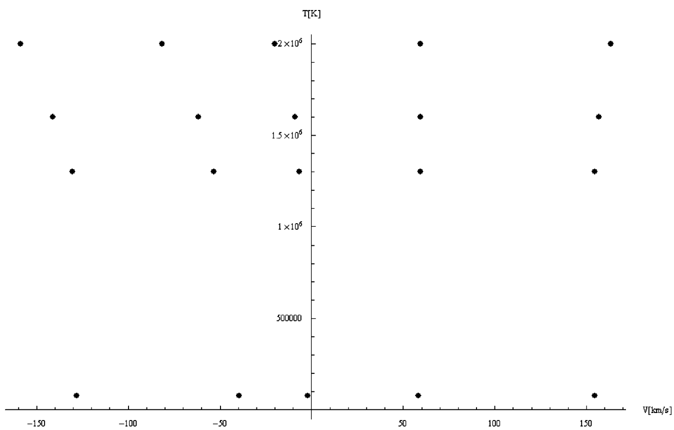

Figure 1. Velocity of the magnetoacoustic shock waves as function of temperature. The scaling is done in 284 Å considering an inter-wavefronts plasma flow velocity of 20 km/s.

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