Magnetically coupled atmosphere, MHD waves transfer, possible contribution to the outer atmosphere heating

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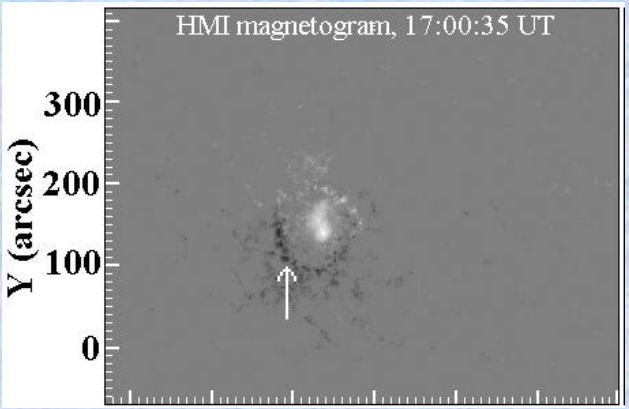
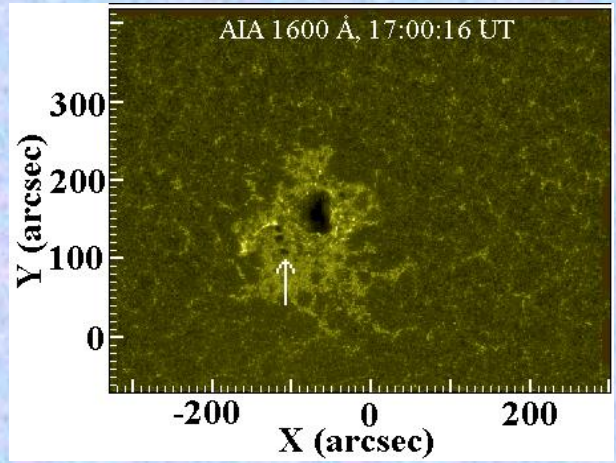
☼ Isolated sunspot of September 10, 2014 flare



- observed by SDO/AIA/HMI and IRIS
- sunspot and pores of positive polarity (in white, HMI)
- group of negative polarity pores (in black, HMI)

GOES X1.6-class X-rays maximum at 17:45 UT
occurred in the NOAA active region 12158
near to solar disk centre
examined during 16:20–18:20 UT interval



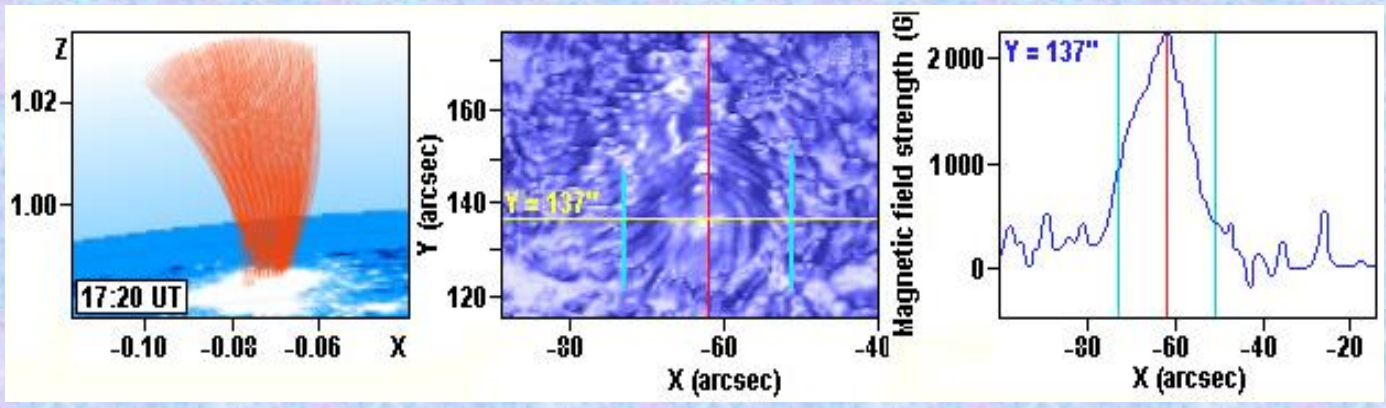
SDO/AIA and IRIS observables:

corona (6 observables)
94 Å, 131 Å, 171 Å, 193 Å, 211 Å, 335 Å

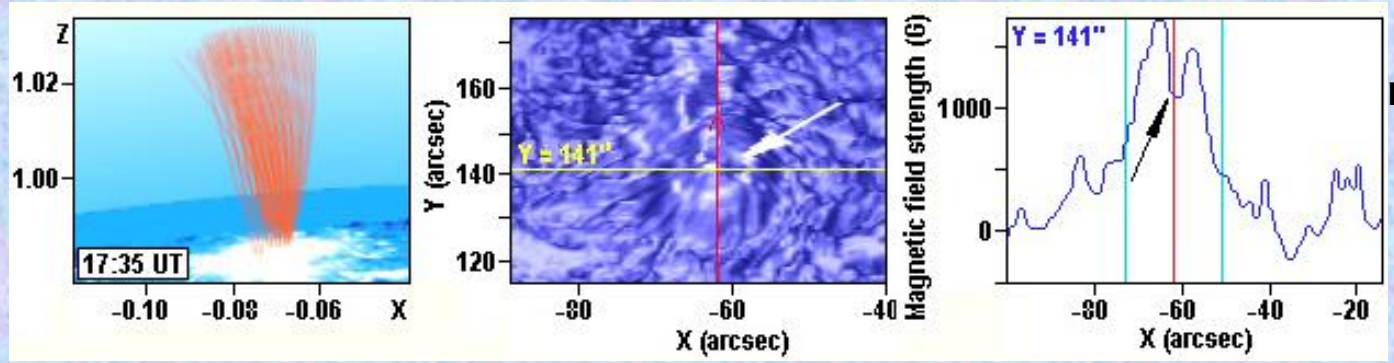
chromosphere and transition region (4 observables)
304 Å, 1400 Å, 1600 Å, 2796 Å

photosphere
1700 Å

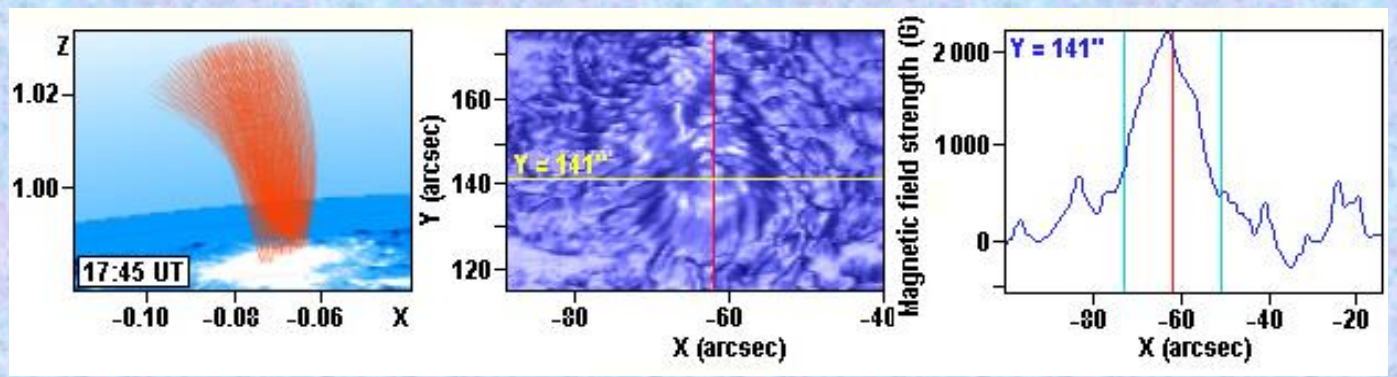
For more details see Mészárosová and Gömöry, A&A 643, A140 (2020)



no magnetic field perturbation



magnetic field lines reconnected (see white arrow)



magnetic field lines relaxation

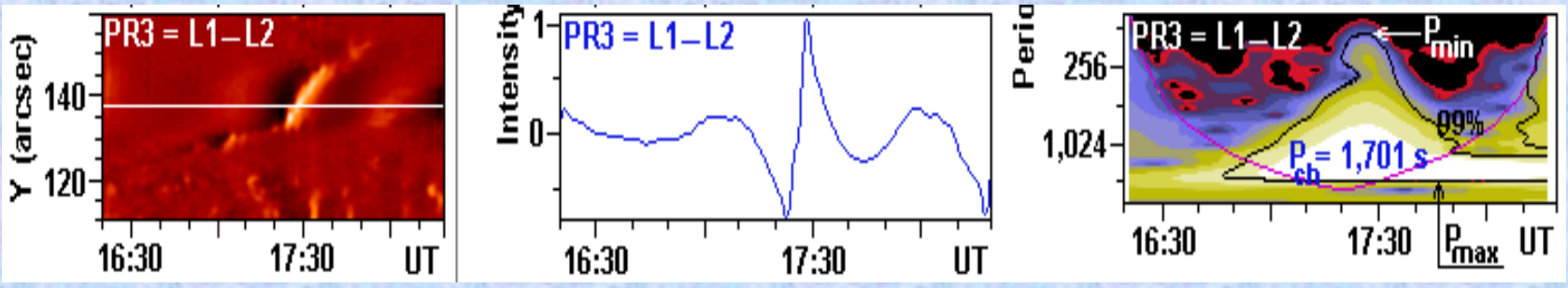
magnetic field flux tube made a magnetically coupled atmosphere

magnetic field strength distributions

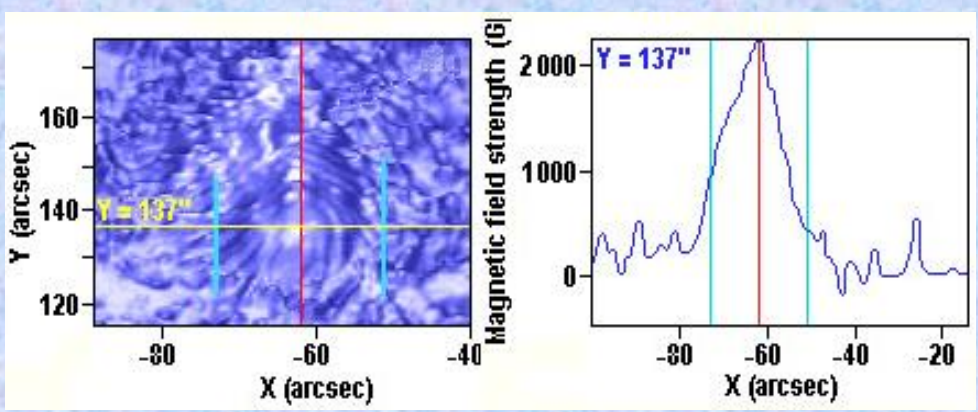
magnetic field strength profiles

For more details see Mészárosová and Gömöry, A&A 643, A140 (2020)

space-time diagram with fast sausage MHD (tadpole) waves



Waves with characteristic periods of 1587-1701 s propagated in cylindrical plasma waveguides of the individual atmospheric layers (photosphere -> corona) were observed by SDO/AIA/HMI and IRIS space instruments.

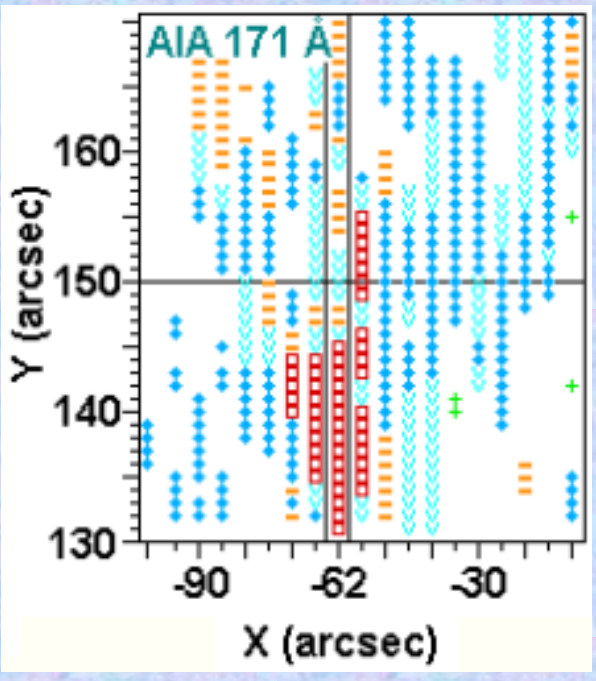


cylindrical waveguide length
L = 11 – 18 km

These waves were observed in the solar corona 192 s later than in the photosphere

waveguide cross-section radius R = 6 – 8 Mm

waveguide width 2R (cyan vertical lines)

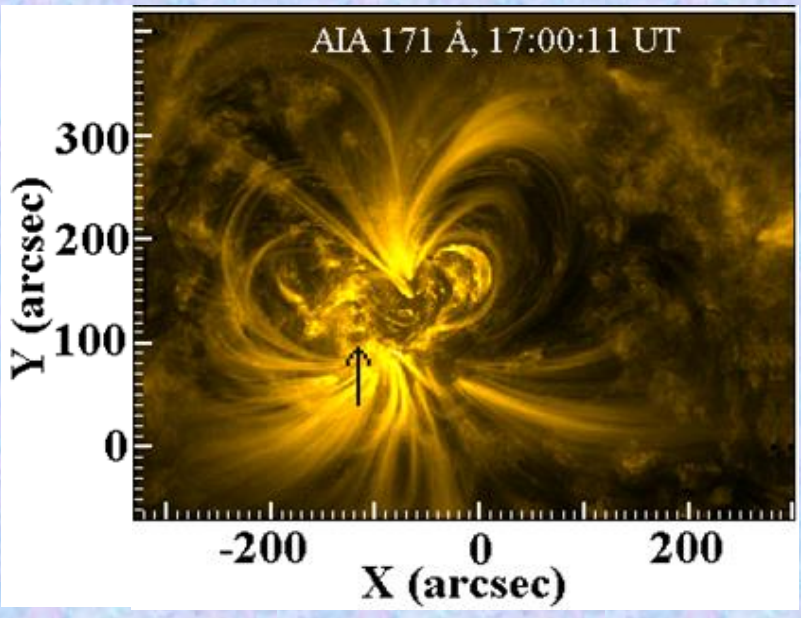


dispersive nature of the tadpole waves

in red = original trapped tadpole waves above the sunspot

other symbols = leakage, tunnelled modes of these waves

The trapped tadpole wave can act as a moving source of the leaky waves and their impulsively deposited energy is released outside the original waveguide



The leaky tadpole waves could play a role in the initial impulses to generate the next generation of the trapped tadpole waves outside the original waveguide. If this process can be repeated, the trapped, leaky, and tunnelled waves could be dissipated throughout the active region.

For more details see Mészárosová and Gömöry, A&A 643, A140 (2020)

Conclusion:

The dispersive nature of the tadpole waves with their easy ability to generate the leaky and other modes propagating outside the original waveguide and magnetic field flux tubes connecting the individual atmospheric layers can distribute the photospheric and chromospheric magnetic field energy across the active region.

This mechanism can contribute to the coronal energy balance and to our knowledge as to how the coronal heating is maintained.

For more details see Mészárosová and Gömöry, A&A 643, A140 (2020)