One-dimensional numerical simulations and observations of MHD wave propagation in the solar chromospheric regions with strong magnetic fields

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0. Abstract

It has been suggested that Alfvén waves, generated in the photosphere and propagating along a magnetic flux tube, can carry enough energy to the upper atmosphere and the dissipation of the waves is one of the possible mechanisms to heat the solar atmosphere. In this paper, we report on our numerical and observational works of the MHD wave propagation in the solar chromospheric region with strong magnetic fields. First, we performed one-dimensional numerical simulations of MHD waves propagating along a strong, open magnetic flux tube in the chromosphere. In order to investigate the dissipation of Alfvén waves, we studied the top and bottom boundaries of the simulated chromosphere. Reflections of Alfvén waves at the photosphere and chromosphere boundaries are observed. The Alfvén waves are trapped in the chromosphere and propagate along the magnetic flux tube, and their energy is transferred to the chromosphere. The propagation of compressible waves in the chromosphere is a major factor in understanding the differences between umbra and penumbra. The effect of magnetic diffusion in the chromosphere is partially explained. Collisions between ions and neutrals cause ambipolar diffusion. Damping of Alfvén waves is caused by ambipolar diffusion. (Matsumoto, T., Shibata, K. 2010).

1. Introduction

1.1 Simulation set-up

1.1.1 1D MHD equations with gravity without resistivity

γ = 5 1/2 μg/cm s²

1.1.2 Initial atmospheric conditions

γ = 5 1/2 μg/cm s²

1.1.3 Background magnetic field structure

γ = 5 1/2 μg/cm s²

1.1.4 Alfven wave generator

γ = 5 1/2 μg/cm s²

1.1.5 Wave propagation

γ = 5 1/2 μg/cm s²

1.1.6 Reflection rate

γ = 5 1/2 μg/cm s²

1.1.7 Power spectrum

γ = 5 1/2 μg/cm s²

2. Estimates

2.1 Damping length by magnetic diffusion

γ = 5 1/2 μg/cm s²

3. Simulation set-up

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4. Result

4.1 Wave propagation

γ = 5 1/2 μg/cm s²

4.2 Reflection at the transition region

γ = 5 1/2 μg/cm s²

4.3 Power spectrum

γ = 5 1/2 μg/cm s²

5. Observation

5.1 Propagation

γ = 5 1/2 μg/cm s²

5.2 Oscillations at umbra and penumbra region

γ = 5 1/2 μg/cm s²

5.3 Apparent propagation speed

γ = 5 1/2 μg/cm s²

5.4 Damping of apparent propagation speed can be seen.

6. Discussion

6.1 Effect of magnetic diffusion

γ = 5 1/2 μg/cm s²

6.2 Sunspot oscillation

γ = 5 1/2 μg/cm s²

7. Summary

7.1 Numerical simulations

γ = 5 1/2 μg/cm s²

7.2 Observations

γ = 5 1/2 μg/cm s²

8. References

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