Response to Reviews for MDPI - January 2023

p-Mode Oscillations in Highly Gravitationally Stratified Magnetic Solar Atmospheres

Thank you for the comments and suggestions for revising our paper. Please find below our responses to each of your comments. Reviewer comments are in bold, our responses are in the lighter colour.

# Review 1

**Referee:**

**1) I have found this manuscript overly lengthy and the findings presented here do not justify the 10 pages of (in essence) introduction to the problem (although it was split in sections 1-4).**

Reply:

The introduction has been restructured and some of the material moved to a discussion section (as advised by reviewer 2).

**Referee**:

**2) The Intro is somewhat chaotic with a strange, at least to me, way to cite publications. usually it is either numbers or names, but not both. Whatever it is, it reads strange at times. For example: line66: "vortex motions have been demonstrated to generate Alfvén waves Fedun et al. [18]." Shouldn't there be some kind of parenthesis? There are many more examples like this, e.g., line 97: "Additionally, it has been suggested that the 5-minute oscillations in loops may not related to sunspots?]." A missing reference?**

**Overall impression is that authors did not really made an effort to present their study in a nice and clean way and that negates impression from the presented study.**

Reply

We have removed some of the content from the Introduction, there has been some reorganisation of the material including the addition of a discussion section. We hope, there is now an improved flow of the content.

We have also changed the references as advised.

**Referee**:

**3) There are words highlighted in bold. What are grain boundaries ? (line 125)**

Reply:

Highlighting should have been removed, apologies. The grain boundaries are the regions separating the grains where convective upflow occurs.

**Referee**:

**4) I don't understand these sentences:**

**"On the other hand, active regions, containing sunspots that have sizes between 1-50Mm, produce flares that may have fields easily exceeding the range of 100-500 G." The flares may have these fields? Sunspots? Are there active regions that contain sunspots <1Mm and >50Mm? Are there 1Mm sunspots?**

**"The 3-minute modes propagate from the photosphere to the chromosphere in the network cell interiors for restricted regions of the network and internetwork." Translation please?**

Reply:

These sentences have now been restructured. The sentence about 3 minute modes was removed in order to reduce the length of the manuscript as advised in point 1.

**Referee:**

**5) Please explain how the plage and the faculae differ.**

Reply

Thank you, this is an interesting question. Solar plage are the bright areas around active regions in the *chromosphere*, whilst solar faculae are small, dotty bright areas mostly observed in the photosphere. However, there is also the notion of chromospheric faculae. . The main difference is that plage are chromospheric features and faculae photospheric features.

**Referee”**

**6) Authors presented their results without properly highlighting their novelty. I would recommend the authors to include a Dicussion section where they clearly state what is new in their simulations and compare their findings against simular efforts if there are any.**

The discussion section has now been introduced, thank you for the suggestion. Other work has also been addressed for improving context and the novelty highlighted. We have not found similar efforts to this work, at least not in the specific sense of the paper.

# Review 2

***This paper is an extension of the work of Malins using p mode in convective cells as driver.***

***The authors define their new model as following:***

***“The initial magnetic field configuration of our model is a standing magnetic tube,***

***passing through the chromosphere and the lower corona.”***

***About the Introduction:***

***You quoted the early work of Jensen and Orrall 1963. However many important papers are missed. The French group made a step forward by analyzing the characteristics of the observed oscillations (phase shifts and determination of the altitude of formation of the chromospheric lines) which has been primordial to reject the acoustic waves as mechanism of corona heating. They showed with observations of oscillations measured in Ca II 8542 A that their period power spectrum was peaked around 180 sec (in the chromosphere mainly at the boundaries of the supergranules (Mein & Mein 1976)), instead of 300 sec measured in photospheric line (Mg I) (Schmieder et al 1977),***

***Magneto acoustic waves have already been suspected as potential candidates to explain the heating of the corona (Mein & Mein 1976).***

***It has been demonstrated that acoustic waves were mainly reflected in the steep gradient of density and temperature of the atmosphere and the theoretical computation of possible dissipation showed that this mechanism was inefficient to heat the corona (Schmieder & Mein 1980).***

**The work of the French group was innovator, and should be quoted.**

Response:

Thank you for the references, we have now referred to the works of the French group. Sorry that we missed this earlier.

**Referee:**

**Recently a study of multi-fluid shows again that in a 1D atmosphere acoustic waves was not efficient to heat the corona (Zhang, Poedts et al 2021).**

Referee:

This reference is an interesting addition. There is more emphasis on solar coronal heating and less about global oscillations as discussed in our paper, we have included a reference to this paper.

**More comments on the paper:**

**The abstract is very clear and well written but over-explains the paper. It does not reflect the content of the paper. The abstract corresponds to what we are waiting for but the paper**

**is not written for supporting the abstract.**

Response:

The abstract has now been modified (simplified) so that it is now an improved reflection of the paper.

**Referee:**

**Section 3:**

**The motivation of the present work is not clearly explained; there is a mixture of 3D existing models (group of Spanish people), your hydrodynamic model and what do you want to do. Please organize your discussion.**

Response:

There has now been some restructuring of the closely relevant literature reviews of existing and past work, to provide a better context of our work. Some parts that we feel important have now been moved to a discussion section.

**Referee:**

**Sections 4 and 5**

**You implement your hydrodynamical model (Griffiths et al 2015) by introducing a magnetic flux tube with constant magnetic field inside. It is a possible exercise.**

**Figures 5 and 6 are interesting. You may be able to go further on.**

**Your discussion with the observations is unclear.**

**“*Also revealed by the simulations was a consistency between power flux measurements from SDO and frequency dependent energy flux measurements from the numerical simulations.”* Could you explain the power flux measurement from SDO? References?**

**Your personal work with AIA does not bring any new argument for your magneto acoustic model.**

**You choose observations of AIA 1600 A formed at the minimum of temperature in low chromosphere -“*This randomly selected region in the solar surface suggests that the observed oscillation is a global phenomenon*”.**

**I am surprised to read that. Since long time we know that the oscillations of 3-5 minutes are a global phenomena, all over the solar surface. This work does not bring any useful argument for your simulation.**

**There is no attempt and no possibility to compare with velocity of propagation.**

The revised paper includes a now table of intensity oscillation periods obtained from the FFT analysis for different AIA frequencies. We have applied the process for different regions. Note, these are lower solar atmospheric intensity oscillations that are different from the well-known 3-5 minute solar global (acoustic) oscillations. The detailed extract below shows three entries for each peak and at each AIA band.

Freq - measured frequency in Hz

Per - period in seconds

Min - period in minutes

|  | 1700 | 1600 | 304 | 171 | 193 |  | below |
| --- | --- | --- | --- | --- | --- | --- | --- |
| freq | 0.00298 | 0.00321 | 0.00085 | 0.00099 | 0.001 |  | 300 main |
| per | 335.5704698 | 311.5264798 | 1176.470588 | 1010.10101 | 1000 |  | 180 main |
| min | 5.592841163 | 5.192107996 | 19.60784314 | 16.83501684 | 16.66666667 |  | biggest |
| freq | 0.00326 | 0.00349 | 0.00113 | 0.0014 | 0.00128 |  |  |
| per | 306.7484663 | 286.5329513 | 884.9557522 | 714.2857143 | 781.25 |  |  |
| min | 5.112474438 | 4.775549188 | 14.74926254 | 11.9047619 | 13.02083333 |  |  |
| freq | 0.00357 | 0.00432 | 0.0017 | 0.00377 | 0.0017 |  |  |
| per | 280.1120448 | 231.4814815 | 588.2352941 | 265.2519894 | 588.2352941 |  |  |
| min | 4.66853408 | 3.858024691 | 9.803921569 | 4.42086649 | 9.803921569 |  |  |
| freq | 0.00398 | 0.00488 | 0.00269 |  | 0.00228 |  |  |
| per | 251.2562814 | 204.9180328 | 371.7472119 |  | 438.5964912 |  |  |
| min | 4.18760469 | 3.415300546 | 6.195786865 |  | 7.30994152 |  |  |
| freq | 0.00426 | 0.00557 | 0.00454 |  |  |  |  |
| per | 234.741784 | 179.5332136 | 220.2643172 |  |  |  |  |
| min | 3.912363067 | 2.992220227 | 3.671071953 |  |  |  |  |
| freq | 0.0048 | 0 | 0.00482 |  |  |  |  |
| per | 208.3333333 |  | 207.4688797 |  |  |  |  |
| min | 3.472222222 | 0 | 3.457814661 |  |  |  |  |

**Referee**:

**The conclusion is definitively very badly written. Some sentences have no verbs other are strange.**

**“*Slow and fast magnetosonic modes are responsible for carrying some energy back to the chromosphere 425***

***and the photosphere. »* What does it mean? Back to the chromosphere? Is it what you want to say?**

Sorry for the poor grammar and inconsistencies. The conclusion has now been reorganised hopefully making clear the novelty of the work. The main points are here, in brief:.

1. Validation of the code, this is a GPU code
2. Demonstration of global oscillations in the *atmosphere* without significant coronal heating
3. FFT analysis demonstrating frequency shifts of simulated results
4. FFT analysis of observational data suggesting frequency shifts

**Referee:**

**Finding global oscillation pattern in the photosphere and in the chromosphere is usual in observations.**

**Your argument to prove that your simulation is correct is to compare the simulation oscillation frequency with this of the global oscillation. But you should explain that you have a particular magnetic configuration with a vertical flux tube; therefore your conclusion about global pattern is not obvious.**

Response:

The hydrodynamic simulations suggestive of global oscillations and energy leakage is enhanced by a vertical magnetic field. Part of the problem is the limited horizontal scale of the model. Indeed, the global oscillations are present in the very low solar atmosphere. But, there is only limited observational studies available whio claim that these oscillations are present also higher up. With our model, we do show the theoretical existence (or expectation?) that these oscillations should be in the atmosphere everywhere. Of course, complex active regions may make this simplistic view more complicated, but at least in the quiet sun, we believe our conjecture prevails.

**Referee:**

**From the observations using the oscillations measured in Ca II lines (see above) it was demonstrated that the propagation of the acoustic waves was possible until the transition zone and the mechanical flux was derived. It was shown that this flux was not sufficient to heat the corona.**

Response:

Yes, this is consistent with what our simulations show.

**What you want to show in your simulation is not clearly described:**

**The introduction of a magnetic field allows you to still keep the pattern of global oscillations in the chromosphere ?? but what is the role of the p mode oscillations in your stratified atmosphere?**

**You did not discuss the propagation in the upper chromosphere?**

We attempt to make clear the presence of global oscillations in the solar atmosphere and we attempt to characterise some of the frequencies found using FFT analysis.

**Conclusion:**

**This paper should be revised to clarify many points: what is the aim of the simulation?. The comparison with their work on SDO/AIA 1600 is not satisfying (page 14- and 17-18 with figure 12).**

**This simulation looks to be an exercise but the applications to observations are far from being convincing.**

**Figure 1 shows magnetic tubes in the network but after that the observations that you use dare active regions and pores. Your simulation could be better adapted to network, plage region, moss in the transition region than to pores.**

The authors are grateful for the comments made by the referees and have significantly rewritten the text and reviewed the analysis. We acknowledge that the work was motivated by the need to further validate our MHD code using a representative test case. It is interesting to consider how the simulation is better adapted to network, plage or moss the transition region. This was one of the motivations for considering FFT analysis for our observational sample in different regions (i.e. active, quiet sun).