Reviewer‘s Dissertation Thesis Report

Chromospheric waves and their contribution to heating of the atmosphere

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The doctoral thesis of Vahid Abbasvand entitled “Chromospheric waves and their contribution to heating of the atmosphere” has in total 122 pages and is divided into eight chapters. The first part of the thesis consists of three chapters containing the introduction to the Sun and the solar chromosphere, the atmospheric models, and spectral lines. The second part of the thesis describes the main results that the author published in three refereed papers submitted to the relevant astronomical and astrophysical journals. In this part, one can find the observations and data analysis and calculated deposited acoustic flux compared to radiative cooling. In the last chapter of the thesis, the author summarizes and concludes the obtained results. A large number of cited papers (in total 154 references) shows that the author is very well oriented in the studied problem. The thesis is ended with a list of figures and tables.
The thesis is mainly focused on the study of the heating of the solar chromospheric magnetic and non-magnetic regions by acoustic or magnetoacoustic waves. The author calculates the deposited acoustic and magnetoacoustic flux which was derived from the chromospheric lines and compared these fluxes with the total integrated radiative losses. The observations of chromospheric lines were done through different layers in the solar chromosphere with the use of Vacuum Tower Telescope, Dunn Solar Telescope, Goode Solar Telescope, and Interface Region Imaging Spectrograph. The acoustic flux was calculated from Doppler velocities in two heights in the solar chromosphere (middle and upper part) and radiative losses by means of 1D non-LTE hydrostatic semi-empirical models. From the obtained results author found two important conclusions concerning the heating of the solar chromosphere in magnetic and non-magnetic regions. In the non-magnetic regions in the quiet chromosphere, the acoustic flux sufficiently balances the radiative losses. On the other hand, in magnetic regions in the chromosphere, the results show, that magnetoacoustic energy flux contributes only 10 – 30 % to the radiative losses and for this reason, the magnetic active-region chromosphere is heated by other mechanisms.
All the results presented in the doctoral thesis were published in well recognized astrophysical journals – two of them in Astronomy and Astrophysics (A&A), one in The Astrophysical Journal

(ApJ), all with scientific journal ranking Q1. Vahid was the first author in all three mentioned papers. The total number of all citations to all his papers is 19 (16 without self-citations, according to Web of Science at the time of writing the report), citations of papers related to the doctoral thesis is 15 (12 without self-citations) and Vahid‘s h-index is 3. In my opinion, Vahid is a promising scientist and it is clear that his work described in this thesis significantly contributed to the field of waves in the solar chromosphere.

Going through the whole text I found only a small number of typos, for example on page 27 the subscripts denoting the electrons i and j should be written in italics, which is correct in Eq (3.1) but not in the text. In Fig. 1.3 a) and b) the black arrows are less visible against the dark parts of the figure. In Figs. 4.4 and 4.5 there is written that “Blue part represents a parabolic fit around the minimum density”, whereas in the text on page 45, last paragraph third sentence, there is written “(orange parts in Figure 4.4 and 4.5)”. However, these typos have no effect on the quality of the thesis.

The scientific topic of the doctoral thesis of Vahid Abbasvand is highly actual and brought important findings in the studied problem of chromosphere heating by (magneto)acoustic waves. I am convinced that the author has demonstrated the ability of independent scientific work and will be a capable researcher. The doctoral dissertation thesis by Vahid Abbasvand Azar has very high quality and deserves to be defended. **I fully recommend that the candidate Vahid Abbasvand Azar, after the successful defence, should be awarded the degree of Doctor of Philosophy (PhD).**

Possible suggestions for questions and comments

Because all the results of the work were published in impacted journals, there is no doubt about the correctness and importance of the results obtained. So I have only a few questions or possible suggestions for further study, arising only from my interest as a person who deals with numerical simulations rather than observations.

1.) In your doctoral thesis on page 79, you mentioned that observed waves have supersonic speed and you interpret them as fast waves. Most likely it is true, but is it possible to prove it by direct observations? I mean that we can distinguish the modes of waves by comparing the thermal (kinetic) and magnetic pressure. If they are in phase, we can say that this could be a fast mode. Would it be possible to observe this effect?

2.) The next possibility how to distinguish, for example, between slow and fast modes of magnetoacoustic waves could be the fact that fast waves propagate in any direction, but slow modes propagate close to the magnetic field. Could it be also observable?

3.) In weak field regions, where the Alfvén speed is lower than the sound speed, the wave energy is transmitted most likely by the fast mode waves, which can be dissipated by shocks depending on the height in the solar atmosphere. Do you think there is any possibility to observe directly these shocks to prove this idea?

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