MASARYKOVA UNIVERZITA

Příloha č. 11

Posudek oponenta habilitační práce

Masarykova univerzita	
Fakulta	Přírodovědecká fakulta
Obor řízení	Teoretická fyzika a astrofyzika
Uchazeč	**RNDr. Petr Jelínek, Ph.D.**
Pracoviště uchazeče	Jihočeská univerzita v Českých Budějovicích
Habilitační práce (název)	Magnetohydrodynamické vlny a oscilace ve sluneční koróně
Oponent	dr hab. Arkadiusz Berlicki, prof. UWr.
Pracoviště oponenta	Instytut Astronomiczny Uniwersytetu Wrocławskiego, Wrocław, Polska

Text posudku

Habilitation thesis of **RNDr. Petr Jelínek, Ph.D.** entitled "Magnetohydrodynamické vlny a oscilace ve sluneční koróně" consists of a short Introduction to the problem of waves and oscillations in the solar atmosphere and description of the current state of knowledge about them contained in Section 1, the description of used codes, studied structures and the scientific results of this habilitation contained in Section 2, and a short summary in Section 3. After this introductory part of the thesis, there is a set of 13 attached refereed papers published in astronomical journals.

The whole content of Introduction (Section 1) is consistent and clear. Large number of cited papers shows that the author is familiar with the literature on physics of waves and oscillations observed in the solar atmosphere. Due to the limited space of the Introduction the descriptions of the waves and oscillations processes are compact and simplified, but sufficient in this context. There are some typos in the text but they do not affect the substance of the content. In summary, the Introduction text is very useful and gives the readers some overview of the theory of oscillatory processes observed mainly in the solar corona.

In Section 2 the author concentrates more deeply on the numerical simulations of MHD waves in the solar corona. This section shortly describes the main results of this thesis. After very compact description of the used numerical codes, there is subsection on the waves and oscillations analysed by the author in different solar structures: magnetic loops, current sheets or null points and in open coronal structures. This section contains also discussion and brief description of the main results of all 13 papers included in this thesis. In this section the author of habilitation also presents some future perspectives and plans for continuation of his work. It is worth to notice that Dr. Petr Jelínek has an ambition plans to use more complicated 3D models with heating and radiative losses components and to continue his cooperation with foreign institutions. There is only one small problem in this section, i.e. References. I don't understand why the author didn't put to the list his own papers cited and described in Subsection 2.2. These papers are only listed in the A.1 attachment and have numbers **J1 - J13**. However, it the text there are quoted without these numbers and therefore it is not easy to identify which citation corresponds to which paper, especially that the **J1 - J13** papers are not quoted chronologically. However, this small inconsistency doesn't influence the results of this thesis.

The last Section 3 of this introductory part of the thesis contains some closing remarks and general conclusions concerning modelling of the MHD waves observed in the solar atmosphere. In this section there is also a short description of recent scientific and pedagogical activities of Dr. Petr Jelínek. This text shows that the author was quite active in his university activities and is well oriented in current problems of MHD waves.

The most important part of the thesis is consisted of 13-refereed papers published in astronomical journals between 2009 and 2016. These papers present the results obtained by Dr. Petr Jelínek and his collaborators (co-authors) and have around 70 citations together (without auto-citations). The work contribution of the author of this thesis to the attached papers is between 10 and 90% and most of these papers were published in highly impacted journals. It is important to notice that in most of highly impacted papers his contribution to the work is dominant. In all 13 attached articles there are several coronal magnetic structures where the waves and/or oscillations were analysed: loops, current sheets, null points and open magnetic structures. Most of the papers contain only theoretical simulations (**J1, J2, J4, J5, J7, J8, J10, J11, J13**), but in others (**J3, J6, J9, J12**) there is also some observational part included and compared with the results of simulations.

The results contained in papers **J1, J2, J11** and **J13** present simulations of acoustic and magnetoacoustic waves in magnetic loops located in the solar corona. These waves are impulsively generated in loops and the resulting evolution of different plasma parameters is studied. In my opinion the most interesting effect is the generation of quasi-periodic processes in the loop plasma. These processes are manifested e.g. by changes of plasma temperature, density and flows. According to the author such changes can be observed with available solar instruments, in particular, the Doppler shifts from moving plasma could be measure and verify the obtained models. Observational verification of the models obtained from the theoretical simulations is always very important and should be done if the appropriate data are available.

In papers **J3 - J6** and **J8** the author concentrate on the numerical simulations of waves propagating in current sheets. Current sheets have been suggested as the possible site for solar flare energy release because they can convert very rapidly the magnetic energy into both heat and directed plasma energy. Also there are electric fields, which can accelerate particles to high energies. Therefore, their modelling is crucial for the understanding of the one of the most energetic phenomena in the solar atmosphere - solar flares. Paper **J3** contains an interesting results showing, in general, that the wavelet spectrum of dm radio emission observed during solar flares show tadpoles structure, interpreted as the presence of magnetoacoustic waves. In case of one event the characteristic period of this structure is 6.3 s and the authors successfully reproduced this period with numerical modelling of waves in current sheet. Such analysis shows that the analysis of dm radio emission from solar flares is a powerful diagnostic tool for the flare current sheets and the characteristic frequency is connected with the current sheet parameters, directly related with the reconnections of the magnetic field during solar flares. In the following papers **J4 - J6**, and **J8** the detailed analysis of magnetoacoustic waves in current sheets and the corresponding wavelet spectra is continued. These papers confirm that the dm solar radio emission from flares contains much information about the physical conditions in the flare current sheets and should be used for verification of the numerical models.

Another important problem is analysed in paper **J7**. The authors performed 2D numerical simulations of waves in open magnetic structures. Such structures can be observed e.g. close to solar sunspots. In these simulations the initial horizontal disturbance occurred low in the solar atmosphere and generated some oscillations with the period of about 3 minutes. Such period of oscillation is commonly observed in the UV and radio emission above sunspots. These results shows another diagnostic possibilities of the plasma located in coronal magnetic field and indirectly give us information about the heating processes in the corona.

In paper **J9** Alfven waves are analysed and the main important result is that such waves can generate plasma jets, which are sometimes observed in polar coronal hole. Paper **J10** contains the analysis of the properties of the perturbation in the magnetic null-point. The important result is that the generated entropy waves can cause the energy accumulation followed by its release during small flares. Such flares or nanoflares are often observed in solar atmosphere and can also contribute to the atmospheric heating.

Finally, paper **J12** is a big review summarizing MHD oscillatory processes occurring in solar atmosphere. This is also very valuable paper, which provide the overview of MHD processes on the Sun. The content of this paper can be useful especially to scientists not specialized in MHD processes and can make complicated physics of MHD more accessible to wider community. The contribution of Dr. Petr Jelínek to this paper is 10%, however taking into account the size of paper (129 pages) and the amount of information contained there, his work was significant.

As can be seen from the whole work of Dr. Petr Jelínek, he is a theoretically oriented specialist in the simulations of different types of waves and oscillatory processes occurring in the solar atmosphere. However, I would like to point that the theory should be always verified by the observations of the modelled structures. Therefore, it could be useful if the author can continue to cooperate with other scientists, who can provide observations suitable for the verification of the obtained models.

In summary, Dr. Petr Jelínek belongs to the elite club of people, who understand the complicated physics of waves and oscillations in plasma contained in the solar atmosphere and can use this knowledge in theoretical simulations of these processes and in interpretation of different observations related to the oscillatory processes. It is clear that the work of Dr. Petr Jelínek described in this thesis significantly contributed to better understanding of physics of waves and oscillations directly connected with the coronal heating processes. Analysis of these processes is very important in the context of better global understanding of the solar atmosphere. He is also very active in the international cooperation and has contact with different foreign scientific institutions. It is especially important in the context of very specialized field, which the author is working on.

Also the other scientific and pedagogical activities of Dr. Petr Jelínek are significant. He had many popular lectures in different high schools or universities. He was also a supervisor of many Bachelor's and Master's theses and had some astrophysical courses for students. Such activity is very important and increases the public awareness of scientific issues.

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Dotazy oponenta k obhajobě habilitační práce:

1. Please, discuss the similarities and differences in the heating mechanisms occurring in the solar chromosphere and the corona. Which mechanisms are most effective in the quiet solar chromosphere?

2. What kind of observations of the solar corona could be useful to disentangle the role of its different heating mechanisms?

Závěr

Habilitační práce **Dr. Petra Jelínka** „Magnetohydrodynamické vlny a oscilace ve sluneční koróně" ***splňuje*** ~~***nesplňuje***~~ požadavky standardně kladené na habilitační práce v oboru Teoretické fyziky a astrofyziky.

V Ondřejově, dne 15.9.2017