Příloha 7: Posudek oponenta habilitační práce

Masarykova univerzita	
Fakulta	Přírodovědecká fakulta
Habilitační obor	Teoretická fyzika a astrofyzika
Uchazeč	RNDr. Michal Varady, PhD.
Pracoviště	Univerzita J. E. Purkyně v Ústí nad Labem
Habilitační práce	Studium slunečních erupcí. Modely a pozorování
Oponent	dr hab. Arkadiusz Berlicki, prof. UWr.
Pracoviště	Instytut Astronomiczny Uniwersytetu Wrocławskiego, Wrocław, Polska

Text posudku (rozsah dle zvážení oponenta)

Habilitation thesis of RNDr. Michal Varady, PhD. entitled "Studium slunečních erupcí. Modely a pozorování" consists of a short introduction (Sections 1-3) and a set of 14 attached papers published in astronomical journals. In Section 1 of the introduction the author shortly describe the main physical processes and models of solar flares. In Sections 2 and 3 the author presents the modelling techniques and observations used in his thesis and shortly describes the main results published in the attached papers no. 1 - 14.

The text of the whole Introduction is consistent and clear. Large number of cited papers shows that the author is familiar with the literature on physics of solar flares. Due to the limited space of the introduction some descriptions of the flare processes are simplified. The description of HYDRAD code could be also more detailed since this code was very important for the obtained results presented in some attached papers. 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 solar flares modelling and observations and, what is even more important, contains discussion and brief description of the main results of all 14 papers included in this thesis.

The second, more important part of the thesis is consisted of 14 papers (9 refereed and 5 non-referred) published in astronomical journals between 1998 and 2014. These papers present the results obtained by M. Varady and his collaborators (co-authors) and have around 30 citations together (without auto-citations). The work input of M. Varady to the attached papers is between 20 and 80%. Five of them were published in highly impacted journals. All 14 attached articles can be divided into 2 groups: more theoretical (11) and observational (3) papers. All papers included in this thesis correspond well to its general topic - modelling and observations of solar flares.

The results contained in **papers 1 - 5** are useful and show, inter alia, direct relationship between the theoretical radiation emitted by the flare structures and the non-thermal time-dependent beam heating function. In future, such results can be used for interpretation of the intensity fluctuations observed in spectral lines and continua emitted from different structures of flares. In is worth to mention that in **paper 1** the real X-ray observations (Yohkoh/HXT) were used to derive the electron beam parameters and then to calculate the

time-dependent response of the solar atmosphere. As a consequence, it was possible to calculate the time evolution of theoretical H-alpha and H-beta line profiles, showing the rapid intensity fluctuations. Such fast variations are observed in reality and therefore the results of **paper 1** can be directly used for their interpretation.

Papers 6 and 7 contain the analysis of the influence of so-called *return current* (RC) on the non-thermal energy deposition in flares. The presence of RC in flares is sometimes underestimated or ignored in the analysis of the flare processes, but these two papers show that RC plays an important role in non-thermal electrons thermalization and their energy deposition in the solar atmosphere. One of the main results of these simulations is that the RC almost immediately balances the beam current. It was also shown in **papers 6 and 7** that RC can change the amount of energy deposited in the chromospheric part of flares. These changes of the deposited energy directly affect the H-alpha line emission, what was presented in **paper 8**. These effects can be very important and should be taken into account in the interpretation of flare spectroscopic observations.

Another important problem is analysed in **papers 9 - 11** of this thesis. It is well known that standard CSHKP and CTTM models of solar flares are not perfect and has problems with the interpretation of some fundamental processes related e.g. to the energy deposition and corresponding hard X-ray (HXR) emission in foot-point regions. Therefore, there are some attempts where the existing models are modified or changed for better explanation of the flare processes and observations. This is rather a difficult problem and **papers 9 - 11**, where such modifications of models were testes, are really important in this context. They show that M. Varady understands well this problem and knows how to deal with it.

Papers 12 - 14 are the observational papers, where M. Varady confirmed that he is also capable to work with the observational data and to obtain some physical parameters of the flaring plasma. It is always very useful to compare the results of simulations with real observational data. Such comparison may support or exclude the proposed model. In my opinion the most valuable is **paper 12**, where the parameters of the flare loops are derived. Such data and important because they can be compared with models calculated with the numerical codes. **Papers 13 and 14** confirm that the magnetic reconnection can really initiate solar flares and present some observational evidences of such process. Although the work input of M. Varady is not the greatest in these papers, the observational confirmation of reconnection process is a challenging task because there are no possibilities of direct observations of the magnetic field lines. These two papers are very useful in this context.

In summary, RNDr. Michal Varady, PhD. belongs to the elite club of people, who understand the physics of radiative transfer and hydrodynamic processes and can use this knowledge in the modelling of the solar atmosphere and in the interpretation of observations. It is clear that the work of RNDr. Michal Varady, PhD., described in this thesis significantly contributed to better understanding of physics of solar flares.

Dotazy oponenta k obhajobě habilitační práce (počet dotazů dle zvážení oponenta)

1. Please, discuss if it is possible, using the work of this thesis, to confirm, or to exclude the alternative heating mechanisms suggested by Fletcher and Hudson (2008, ApJ, 675, 1645).

2. It is frequently observed that after the maxima of big solar flares the solar chromosphere remains bright even many hours after the flare onset. What are the possible heating mechanisms, which could be responsible for such long-duration emission of the flare chromosphere?

3. What kind of flare observations could be useful to disentangle the role of return current during the impulsive phase of solar flares?

Závěr

Habilitační práce Michala Varady „Studium slunečních erupcí. Modely a pozorování“ ***splňuje – ~~nesplňuje~~*** požadavky standardně kladené na habilitační práce v oboru Teoretické fyziky a astrofyziky.

Wrocław, dne 28.1.2015

Arkadiusz Berlicki (podpis)