Report on the doctoral thesis.

Title: "Velocity fields in the solar photosphere"
Candidate: Mgr. Michal Švanda

Report given by: **Dr. Aleš Kučera,**
Astronomical Institute of the Slovak Academy of Sciences,
05960 Tatranská Lomnica, Slovakia

1) General impression of the content and scope of the work.

The topic of the thesis is up-to-date subject in the current solar physics research. The velocity fields, namely large-scale flows in the photosphere and in sub-photosphere layers, are in close connection with the dynamics of the Sun, with solar activity cycle and solar magneto-convection. In spite of great effort in the last decade, the fundamental physics of those phenomena still remain unclear.

Methods, data, and interpretation used in the thesis and results obtained, are on high level and fully reflect the modern research in the solar physics. The candidate also demonstrated very good overview of the state-of-art of the topic under study.

Methods: The candidate uses standard method so called "Local Correlation Tracking" (LCT), commonly used in the research field but the original code developed by candidate for generating synthetic data introduced very good tool for precise reduction of observing data and determination of accuracy of the results. Thus the synthetic code developed by candidate set the LCT to higher level. Careful comparison of the new method and standard procedures applied on the same observational material fully demonstrated the quality and applicability of the new tool.

Data: The data used in the thesis, mainly SOHO/MDI belong to the best ones in today solar physics even they suffer by some inaccuracies. Selected data, time series of MDI Dopplergrams, as well as data for solar eruptive filament are suitable for the aims outlined in the thesis.

Interpretation and results: The candidate first presented results comparable with previous ones from other authors, but he obtained them with a new method. In several particular cases ("Long-term behaviour of velocity flows", "Motions around the foot-points of the eruptive filament" and "Meridional magnetic flux transport") he presented new results contributing to general knowledge on the processes taking place on the Sun.

As a main achievement of the thesis I appreciate:

1) Introducing a new method for analysis of a large scale flows in the photosphere, which is fully comparable with commonly used method(s) and very promising for future.
2) Precise processed data with careful estimation of any possible errors and influences.
3) The results concerning the motions around the foot-points of the eruptive filament.

2) Criticism, comments, advice, and questions to candidate.

The criticism and comments in general are of minor importance in comparison to the very positive evaluation of the whole work. The questions, which should be answered by the candidate are given in bold.

1) Even the Chapter 8 – "Meridional magnetic flux transport" is interesting and results are important, it looks to be not an integral part of the Thesis. In this chapter, different method to that developed and described in the Chapter 3 is used and its deal mainly with magnetic flux transport.

2) Contrary to that, the work given in Appendix, seems to me more close to the topic of the thesis, and could be integral part of the Thesis even it is, as the author said "in the very early stage".

3) Chapter 3, the description of the SISOID code: Author described here in fact two velocity regimes. i) The "internal velocities and lifetime" of supergranules well defined and demonstrated on page 14 and in Figures 2 and 3, and ii) "the model vector velocity field" mentioned on page 16 and 19, but not described more in detail. From the text in the Chapter 3 it is not clear what exactly bears the "*model vector velocity field*". In the paragraph 2 on page 16 author says "*The model velocity field with Carrington rotation added is applied*", then on page 17 paragraph 2, "*The primary data* (here mentioned the synthetic data) *must be pre-processed by removal of the manifestation of the Carrington rotation and by the suppression of the p-modes*" and then – page 18 top, "*...the tild ...b_0 is also removed*". Finally (page 19 sec. 3.3), "*In our tests we have used lots of variations of simple axisymmetric model flows with ...parameters describing the differential rotation and meridional circulation*". From the above mentioned sentences follows, that the "*model vector velocity field*", applied on the synthetic supergranular population, bears: *the differential rotation, meridional circulation, tild b_0, Carington rotation* and *p-modes*.
Is that true? Can the author better define and describe both, the *"model vector velocity field"* and some variation of it used in synthetic data experiment?

4) Figure 5, simulated Dopplergram:
What causes the several very bright spots in the simulated Dopplergram?

5) The author uses in the synthetic data **fixed supergranule lifetime profile** (fig 2, left) and mentioned that he tested the sensitivity of the method to the choice of values of FWHM of the correlation window (spatial) and of the lag between correlated frames (temporal) and the best choice was the lag 16 (4 hours). It was shown by DeRosa and Toomre (ApJ, 2004, **616**,1242) that the **supergranular lifetime depends on the temporal averaging window** (fig. 17 in the paper).
Can this fact influence (and if yes, how much) the results obtained from simulations made with different lags between correlated frames using still *fixed supergranule lifetime profile*?

3) Minor comments and inaccuracies

1) Chapter 3, spatial resolution: there is not explicitly given the spatial resolution of the synthetic Dopplergrams. Only from the info that "*...FWHM 30 pixels equals 60" on the solar discs*" one can resumes the resolution 1 pixel = 2"

2) Definition of the parameters and uniform usage of them:
Use only one form of spelling for model velocity field. Page .16, "*vector velocity field; model vector velocity field; model velocity field*, p.19, simple axisymetric *model flows*, fig. 7 *model field* ...
Similarly use one form for calculated (resulted) velocity field c.f. fig. 7 and fig 9, *velocity field that was computed* ; *calculated velocity field* and fig. 16, left – *velocity field*, right – *vector field*

3) In connection with the evolution of the synthetic granules, p. 14, the last paragraph.
What does it means "... any of the supergranules located at the vertices of the triangle is not *to young*....? *Can this "to young" be expressed by the value (or by fraction) of lifetime of granules?*

4) Several figures should be much bigger than in the present version to be able to see details on them. Especially the figures, 22, 32 and 33,

5) Also figures 36, 37, 42, 44, 46 would be better to be larges or to have even bigger description of axis.

6) In some of the images, it would be useful to give colour bars for demonstration of distribution of given quantity through the full data span. (figs 5, 19, and it may be fig. 46.) Especially in the fig. 5, it seems that the white spots in the simulated Dopplergram being set to value + 700 m/s suppressed all other values in the Dopplergram.

7) Figure 2, y axis: Counts in %.
What does it mean counts? Is it frequency N = (*number* of supergranules with given lifetime) expressed in percent of the total number of supergranules? (or in percent of the total lifetime in hours?)

4) Conclusion

The criticism and comments mentioned above are of minor character. Mgr. Michal Švanda fully demonstrated his ability for scientific work, his PhD. thesis definitely fulfils the criteria for PhD. thesis.
I recommend that the candidate obtains the PhD. degree after successful defense.

Huntsville, October, 24, 2007 RNDr. Aleš Kučera, CSc.