Assessment of Mgr. Andriie Lynnyk's doctoral thesis
„Evolution of Interplanetary Coronal Mass Ejections"

1. Aim of the thesis

The thesis aims at studying interplanetary coronal mass ejections (ICMEs), in particular their magnetic clouds (MCs), as they move inside the solar wind and in the heliosphere. Whereas the velocity of the solar wind varies from 400 km/s to 800 km/s – being dependent on the phase of a solar cycle and heliographic latitude – that of IMCEs/MCs lies within a much bigger range: from 200 km/s to 2000 km/s. This discrepancy in velocities leads to deformations of IMCEs/MCs as they propagate through the heliosphere; the nature of these deformations is undelaid by interactions of particles of the solar wind with magnetic fields of ICMEs/MCs and their shape is a function of the distance from the Sun and a relative velocity of ICMEs/MCs. As some ICMEs/MCs also hit the Earth's magnetosphere and cause its disturbances, the theme of the thesis is also important from the point of view of possible applications.

2. Originality and level of the thesis

The thesis is written clearly and systematically and represents a coherent piece of work. It comprises five chapters. Chapter 1 gives a brief description of well-established properties of solar wind, ICMEs and MCs, as well as the shapes, models and expansions of MCs. Chapter 2 describes the main themes to be addressed, in particular deformations of IMCEs/MCs as they propagate in the heliosphere. Chapter 3 deals with the methodology of the selection of observations of IMCEs/MCs acquired by the space probes Wind (for the periods 1995-2003 and 2007-2011) and Voyager 1 and 2 (for the period 1977-1989). The total of 168 observed ICMEs/MCs covering the distance from 1 AU to 30 AU were selected, out of which 26 were further carefully analyzed. Chapter 4, the core of the thesis, provides the analysis of the selected cases. The main focus is on the expansion of an MC as a function of its distance from the Sun, the change of its shape due to interaction of its magnetic field with the external magnetic fields dragged by solar wind and the ambient IMCE, and deformations of both the MC and its ambient IMCE. The models employed are more complex that those used before, as they not only take into account the role of magnetic fields, but also specific geometric properties of IMCEs/MCs (their helical structure). The main input parameters were magnetic field strength - three components in the GSE coordinate system, velocities of the MC and solar wind, and proton density and thermal speed. The agreement with observations was found to be better than for earlier simpler models. Chapter 5 summarises the main findings, which in the meantime have been published in an internationally-recognized journal, and stresses that the methods/models proposed by the candidate lead to several novel phenomena associated with IMCEs/MCs, e. g. if the magnetic field inside the IMCE/MC is much stronger than that in the ambient solar wind, the IMCE/MC cross-section is closer to circular.

Concerning the formal aspects of the written presentation, the layout and structure are appropriate, the exposition of the ideas is well-organized and all the relevant references are properly cited.

3. Results accomplished

All the aims of the thesis were successfully accomplished The candidate has clearly shown the ability and skills to conduct a major intellectual study and to arrive independently at successful conclusions.

4. Comments

There are a few typographical errors to be corrected, but this is just a matter of quick spell-checking. I have also a question: Could you, please, explain what is behind a rather big scatter of the values for R_C/R in Figure 4.14?

5. Conclusion

In light of what has been said above, I consider the candidate to be very well acquainted with the research field and subject matter of the thesis and given the high quality of his research, originality of the approach and envisaged impacts on the field in question, I whole-heartedly recommend him to be authorised to defend his thesis, which I am sure he will do convincingly and lucidly.

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