September 7th, 2024

doc. RNDr. Mirko Rokyta, CSc.
Dean of Faculty of Mathematics and Physics
Charles University
Prague

Subject: Evaluation of the Doctoral Thesis by Marta García Rivas

Dear Dr. Rokyta,

As requested, I have carefully reviewed the doctoral thesis titled **"Interaction between Solar Convection and Magnetic Fields"** by Ms. Marta García Rivas. After a thorough analysis, I am pleased to present my evaluation of the research, its scientific contributions, and the candidate's overall performance. Please find below different aspects I evaluated from this work:

1. Scientific contribution
The thesis focuses on exploring the magnetic properties of solar structures, specifically pores and sunspots, and examines the interplay between magnetic fields and solar convection. It provides novel insights into the behavior of the vertical magnetic field and total magnetic field at the boundaries of pores and umbrae, presenting findings that expand upon and deepen our understanding of the Jurčák criterion. This criterion, which connects the stability of sunspots and pores to a critical value of the vertical magnetic field, serves as a central theme throughout the thesis.

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The thesis is structured around three main research papers:

Magnetic properties on the boundary of an evolving pore – This article reveals that, similar to, sunspots, pores exhibit a critical vertical magnetic field value, which governs their stability. The study details the evolution of a pore through distinct phases (formation, stability, and decay), demonstrating that pore regions with vertical magnetic field lower than 1731 G are prone to disintegration faster than those with stronger vertical fields.

Magnetic properties of the umbra boundary during sunspot decay – This work offers a comparative analysis of datasets from Hinode/SP and SDO/HMI, highlighting the differences in magnetic field measurements between instruments and documenting the sunspot decay process. It establishes that sunspot decay occurs in two stages—an initial slow phase followed by a rapid decay—while drawing key parallels between sunspot and pore magnetic evolution.

On the onset of penumbra formation – This article investigates the formation of penumbral filaments in a protospot and describes the flow patterns that precede and accompany their development. The findings suggest that penumbral filaments form near the umbra boundary, where the vertical magnetic field is lower than the critical value, and expand radially outward, with the Evershed flow setting in rapidly once the penumbra forms.

2. Originality and novelty

The research work provides an original and important contribution to the field of solar physics. The research introduces novel insights into the transition between magnetoconvective modes in solar structures, revealing how pores and sunspots undergo similar evolutionary processes but exhibit key differences in their decay dynamics. The work on the rapid formation of penumbral filaments is particularly innovative, as it sheds light on the formation stages of these features with high spatial and temporal resolution.
The systematic approach of comparing multiple datasets from space-based and ground-based instruments (HMI/SDO, SP/Hinode, and GFPI/VTT) also enhances the robustness of the conclusions. The analysis of the instrumental discrepancies provides valuable clarification for future studies on sunspot and pore evolution.

3. Importance for the field and potential applications

The findings presented in this thesis have significant implications for the broader understanding of solar magnetic fields and their role in solar activity. By improving our knowledge of the stability criteria for sunspots and pores, the research provides critical insights that can inform predictive models of solar activity, such as sunspot formation and decay, which are fundamental for

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understanding space weather and, ultimately, its impact on Earth's magnetosphere.
Furthermore, the work has potential applications in refining models for solar dynamo theory and understanding magnetic field emergence, with future prospects of applying these insights to the study of other stellar magnetic phenomena.

4. Methodology
The methodology used throughout the thesis demonstrates a high level of scientific rigor. The candidate applied sophisticated spectropolarimetric data analysis techniques, including Milne-Eddington inversions and the use of inversion codes like VFISV, MERLIN, and SIR. The temporal and spatial resolution of the datasets, combined with the correction for scattered light in HMI data, allowed for a detailed and precise study of the magnetic properties of solar structures.
The comparative approach between datasets from different instruments further strengthens the reliability of the results. The author was meticulous in addressing discrepancies between instruments, especially in the analysis of magnetic field and continuum intensity, which leads to a clearer understanding of the phenomena being studied.

5. Form and presentation
I consider the thesis is well-organized and clearly written, with each chapter transitioning logically from background information to detailed analysis and discussion. The figures and graphs are thoughtfully designed and support the narrative effectively, contributing to a clear understanding of the results. The presentation of the work meets the high academic standards expected for a doctoral dissertation.

6. Creative and independent scientific work
The research demonstrated creativity and independence in scientific work. The choice to focus on the magnetoconvective properties of pores and sunspots, as well as the innovative examination of penumbral filament formation, reflects the author's capacity for original thought and problem-solving, with the use of observational data and applied cutting-edge techniques to address longstanding questions into the behavior of solar active regions.

7. Conclusions
After evaluating the research, I can conclude that Ms. García Rivas has presented a thesis that makes a significant contribution to the field of solar physics. Her findings on the critical role of vertical magnetic fields in the stability of pores and sunspots, the decay dynamics of these structures, and the formation of penumbral filaments offer valuable insights that will benefit future research.

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Although the primary focus of the work is on the magnetic properties and evolution of sunspots and pores, the author's work on solar flares included as an appendix, particularly the study of flare-induced chromospheric heating, stands out as a significant and valuable contribution. Though this research deviates slightly from the core topic of this thesis, it demonstrates the author's ability to extend the scope of her work and contribute valuable findings to the study of solar flare dynamics. The detailed multi-wavelength approach and focus on the rapidly evolving nature of flares make this section of the work a valuable complement to the thesis, expanding its scientific relevance.

Overall, the quality of the work demonstrates that Ms. Marta García Rivas is fully prepared for independent research at the highest level.

Please feel free to contact me if further clarification is needed.

Yours sincerely,

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