

## Jury Member Report – Doctor of Philosophy thesis.

**Name of Candidate:** Galina Chikunova

**PhD Program:** Engineering Systems

**Title of Thesis:** Coronal dimmings associated with coronal mass ejections: evolution, lifetime, and relation to the directivity

**Supervisor:** Associate Professor Tatiana Podladchikova

**Name of the Reviewer:** Dr. Henni Ouerdane, Associate Professor

I confirm the absence of any conflict of interest

(Alternatively, Reviewer can formulate a possible conflict)

**Date:** 16-11-2023

*The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.*

*If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.*

### Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.

The doctoral thesis is composed of 8 chapters including Introduction and Conclusion, as well as a preamble that states the research question and the objectives of the doctoral work. While the core topic is that of coronal dimming, the Introduction is dedicated to the Sun and basic solar physics. This allows for a comfortable reading of Chapter 2, which focuses on the description of coronal mass ejections. Chapter 3 is a very short one explaining the basics of coronal dimming. The chapters that follow present in a very well-organized fashion the work done: the methodology developed and implemented for the dimming analysis, the relation between dimming and coronal mass ejection speed and mass, the dimming lifetime, and the relation between dimming and the coronal mass ejection direction. The bibliography is extensive and provides useful references allowing the reader to have a good vision of the specialized doctoral work in the broader context of the scientific field.

- The relevance of the topic of dissertation work to its actual content

The study of coronal mass ejections from the Sun provides valuable information on the star's properties and their dynamics but is also of high importance for the understanding of our solar system environment and for space weather prediction. The latter is of practical importance as it allows to estimate the possible impacts of a coronal mass ejection on Earth. The actual thesis content is perfectly relevant to the topic and problems addressed during the doctoral studies. The research questions have been clearly formulated, the methodology rigorously developed and explained, the obtained results clearly presented across the manuscript, and the answers to the questions well stated in the Conclusion.

- The relevance of the methods used in the dissertation

A coronal dimming is an event that takes place in the lower corona and manifests itself as reduced emission of soft X-rays and of extreme UV radiations. They indicate that coronal mass has been ejected as both loss of mass and temperature variations are observed. A central problem is then to analyze the dimming properties (area, intensity, lifetime, and the associated magnetic flux) to the characteristics of the coronal mass that has been ejected: mass, speed, direction.

The dimming analysis methodology developed during the doctoral work is presented in full in Chapter 4. The work rests on the data provided by the Solar Dynamics Observatory, the Solar TERrestrial RELations Observatory, and the Extreme-Ultraviolet Imaging Telescope. The framework proposed for dimming data analysis is based on tools developed with the Python Sunpy library. Sunpy provides an open-source environment for solar data analysis and it is a reliable one, which has been employed, tested and developed by the solar physics community. The developed method has been applied to produce the results presented in the thesis and published in top journals.

- The scientific significance of the results obtained and their compliance with the international level and current state of the art

The scientific significance of the results obtained during the doctoral work and how they comply with international standards and the state of the art is demonstrated by the publications of articles in top journals and presentations to peer-reviewed international conferences of high standing. Of particular interest is the methodology that has been developed and implemented numerically to analyze dimming.

- The relevance of the obtained results to applications (if applicable)

The research questions stated at the beginning of thesis have been answered. The obtained results are of high relevance for space weather forecasting as coronal dimming has been shown in this thesis to provide much relevant data and information about coronal mass ejections, which can perturb strongly the Earth's upper atmosphere and produce adverse effects.

- The quality of publications

The results of the doctoral work have been published in top peer-review international journals and presented at reputable conferences, which indicates a very good quality of the obtained results. The candidate is the first author of the two published articles that are the pillar of the thesis, and co-

author of two other published papers closely related to her doctoral work. She is also co-author of another two manuscripts under consideration by a top journal of the field.

The summary of issues to be addressed before/during the thesis defense

I have no criticism to make about the scientific work, which is sound and the results of which are discussed in sufficient details. I also appreciate the reflection proposed at the end of the conclusion chapter on the possible extensions of the work which seem promising. My (light) criticism rather concerns the thesis manuscript and takes the form of comments for optional consideration.

- Separating the preamble Thesis Objectives from the Introduction Chapter, which has more to do with heliophysics, is a choice that can be discussed. In fact, the thesis could have been organized as follows: Introduction that would give a brief overview of the field of research and state some of the current outstanding questions and research gaps, which would then lead to the statement of the research question and the outline of the thesis manuscript; this would be followed by a Part I Basic of heliophysics, which would contain the current version of Chapter 1 and Chapter 2 merged with Chapter 3; Part II where the actual research work is developed at length would contain the current Chapters 4, 5, 6, and 7. The thesis would then end with the current Chapter 8.
- In relation to the above point, while this is not an issue per se, given the small size of Chapter 3, I believe it would fine to merge it with Chapter 2, which could be renamed Coronal mass ejection and coronal dimming. The resulting chapter would not be too bulky and would be comparable with other chapters in terms of length.
- In the reference section, DOIs are given for some references but not for others. This should be fixed either by giving all DOIs with links (preferred option) or removing them all (ok, but not preferred).

**Provisional Recommendation**

*I recommend that the candidate should defend the thesis by means of a formal thesis defense*

*I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

*The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*