REPORT
on the Dissertation of Ing. Martin Matys
"Novel Schemes in Ion Acceleration Driven by High-Intensity Lasers"

This Report is prepared following the request from Doc. Ing. Václav Čuba, Ph.D., Dean of the Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague. It is itemized as suggested in the request.

The Dissertation consists of 5 Chapters, Acknowledgements, Bibliography, and 4 Appendices. The Chapter 1 introduces the problem, that is the laser-driven ion acceleration, and describes how the author's work contribute to the solution of the problem. The Chapter 2 briefly reviews the known analytical models (mechanisms) of ion acceleration in laser-matter interactions. The Chapter 3 describes the numerical scheme of the Particle-in-Cell (PIC) method and some techniques of data post-processing, also mentioning visualization. The Chapter 4 merely briefly reviews the five papers coauthored by the author adding very little to the contents of those papers. The Chapter 5 repeats the goals stated in the Chapter 1 and very briefly mentions future prospects. The Appendix A is the list of the authors' publications (easily verifiable); the Appendix B is the list of the authors' presentations at scientific conferences (not easily verifiable); the Appendix C contains the reprints of five coauthored papers (briefly reviewed in the Chapter 4); and the Appendix D is for author contribution statements. The Dissertation contains many blank pages.

- how much the topic of the thesis is up to date
The Dissertation is devoted to a very interesting (all-optical) laser-driven (heavy) ion acceleration beyond 100 MeV per nucleon. While being demanded by numerous applications, it is not yet experimentally realized to the state suitable for applications. The results presented in the Dissertation show the approaches that bring the experimental realization and possible applications closer. Therefore, the topic of the Dissertation is up to date.

- what are the methods applied in the thesis
The Dissertation is based on analytical models of theoretical physics well described in the Chapter 2, on numerical simulations performed with methods described in the Chapter 3 (Section 1), and on post-process and visualization techniques scantily described in the Chapter 3 (Section 2).

- whether the goal of the thesis has been achieved
The goals of the Dissertation are indirectly mentioned in the Abstract, then explicitly stated in the Chapter 1 (Section 2), and repeated in the Chapter 5 (Section 1). They stated as follows: "to investigate the novel schemes of ion acceleration, available via the use of high-intensity laser pulses, with the help of particle-in-cell (PIC) simulations." More specifically, three schemes with special targets are considered: (1) low-density cryogenic target, (2) double-layer target with spatially modulated interface, and (3) thin targets for laser pulse shaping and ion acceleration.

These three schemes are investigated as follows. Basing on the analytical models, setups for numerical simulations are prepared and initial parameters are chosen; then 2D and 3D simulations with the EPOCH code using the PIC method are performed; the simulation output is post-processed and visualized using various numerical techniques; the obtained results are interpreted using the analytical models; the sequence may be repeated if necessary for the parameter dependence investigation and/or for optimization. In this process the new important features were found, such as the phenomenological scenario and topological aspects of the laser-matter interaction, and quantitative characteristics of the interaction (in particular, charged particles' energy spectra).

Thus, the goals of the Dissertation are achieved, at least in the sense that the obtained results represent sufficiently detailed directions for future experiments and thus show the way to obtain laser-driven ion beams desired by applications.

- what is the scientific value of the results

The Dissertation is of high scientific value. Quite obviously, the above-mentioned new features found in the Dissertation are inaccessible for the described analytical models due the model limitations (low-dimensionality, imposed symmetry, and too restrictive approximations), although they are inspired by those models. Moreover, many features that can be seen in simulations in general, and in this particular Dissertation, are also inaccessible in experiments due to diagnostics limitations. At the same time these new features are obtained with well-defined scientifically valid numerical simulations based on the first principles of theoretical physics. Thus, they and their corresponding description are verifiable. Therefore, the finding of the Dissertation presents the important scientific prediction.

The scientific value of the results presented in the Dissertation is also directly demonstrated by the fact that these results are published in scientific journals with high impact-factors.

- what is your overall evaluation on the thesis, i.e. whether you recommend it for presentation and defense or not

As a scientific monograph, the Dissertation lacks the proper description of work behind the papers attached in the Appendix C (as is well known, a paper in a scientific journal is usually an extremely concentrated representation of real substantial work). In particular, post-process and visualization techniques (e.g., virtual reality) are described very scantily; their important role in understanding physical phenomena and a correct interpretation of simulation results is not properly described (and seemingly not mentioned as a distinctive merit). This can be a shortcoming for educational purposes. However, this eased the reviewing process for me, because the material is shorter. Anyway, the Dissertation contains more than sufficient scientific material.

Summarizing, it is my pleasure to recommend this Dissertation for presentation and defense.

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