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12 January 2019

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**Re: Evaluation report of habilitation thesis by Dr. Jan Pšikal**

The habilitation thesis of Dr Jan Psikal presents a well-organized, detailed review of his work on one of the major avenues of contemporary research with high-power lasers: namely, ion acceleration. Given the worldwide interest in this topic, where the goal is to exploit the high electric field-strengths attainable with petawatt-class lasers to create compact, high-brightness sources of ion beams suitable for imaging or radiography, this is a timely contribution to the field. Dr. Psikal's thesis comprises five theoretical works in which he has been principle investigator, and three experimental works where he has contributed substantially to the theoretical analysis and interpretation.

The thesis is organized in three main parts. The first of these (Chapter 2) presents a concise, well-referenced summary of the main numerical method – particle-in-cell simulation – used by Dr. Psikal and his co-workers to study the dominant physical processes relevant to laser-ion acceleration. Here the reader can also find practical details on everyday usage of this simulation technique, as well as reference to other methods in the plasma modelling hierarchy. Chapter 3 summarizes the main ion acceleration mechanisms (sheath acceleration, radiation pressure, magnetic vortex acceleration etc.) which have emerged over the past 20 years, giving the principle scaling laws of each. Here it would have been useful to see a chart comparing the different theories and their realm of applicability. I also would have been interested to see an experimental overview and some comment on the disappointing lack of progress over this period compared to similar efforts in electron acceleration. The final part (Chapter 4 and collected papers) provide the substance of the thesis, exploring a number of ion acceleration mechanisms and combinations of laser sources and complex targetry.

Considering the first five papers presented, what stands out is that Dr Psikal has examined nearly all of the major acceleration mechanisms of contemporary interest. Despite the fact that each of these has received a lot of attention, he has still managed to identify a number of new aspects or features which were overlooked before. A typical example here (Paper 3) would be the re-examination of relativistically induced transparency (RIT) regime with a frequency-tripled ($3\omega$) pump laser, reducing the effective laser intensity required to penetrate a nominally overdense plasma slab and ultimately predicting a 2-fold increase in the number of high-energy (100-200 MeV) protons produced. Another important prediction (Papers 1,5) is the increasing dominance of radiation pressure acceleration (RPA) over rear-side sheath emission – regardless of laser polarization – for the multi-PW laser systems which are just becoming available. In all of these works, a common feature is the choice of special target composition or geometry, which contributes to enhancements of either ion/proton energies or number or both.

Finally, it is also apparent that Dr. Psikal has had a significant role to play in the experimental works presented here, since all three experiments are directly related to one or more of the theory papers, sharing certain features of the targetry in each case (nanostructures, nanospheres and solid hydrogen ribbons respectively). These contributions should not be underestimated, for it is only through these numerical simulations that the dominant physical processes occurring during the experiments can be identified and understood.

The popularity and competitive nature of this subject means that it is not easy to make a mark with original ideas and discoveries. Nevertheless, the articles authored and co-authored by Dr. Psikal over the past 5 years for this collection certainly demonstrate a flair for pursuing and directing original lines of research. In particular, he has chosen to focus on novel target designs in pursuit of potential enhancements in the competitiveness of laser-produced ions acceleration, gaining new insight into the physics and bringing this technology a step further to adoption for everyday applications. For these reasons I can wholeheartedly commend this thesis as fulfilling the requirements for a habilitation degree.

Yours sincerely,

Paul Gibbon