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Object: assessment of PhD manuscript of Mr. Marcel Lamač

To whom it may concern,

I am writing to provide my evaluation of the PhD thesis submitted by Mr. Marcel Lamač, which falls within the domain of high-power laser and plasma physics. The thesis is a well-organized and authoritative account of his research, notably focusing on the physics of remarkable physical systems known as 'relativistic plasma mirrors'. I found the manuscript both highly engaging and impressively written, with a clear and logical structure across its three chapters.

In **Chapter 1**, Mr. Lamač introduces the context of his research with a concise overview of the development of high-power femtosecond lasers, demonstrating how these advancements have opened up the new field of ultra-high intensity physics. This sets the stage for the following discussions, establishing a solid foundation for the reader.

In **Chapter 2**, he provides a comprehensive state-of-the-art review of ultra-high intensity physics, beginning with the theory of relativistic optics and progressing to the interaction between high-power lasers and matter, whether solid or gaseous. The clarity and depth of this review highlight Mr. Lamač's strong grasp of the subject.

In **Chapter 3**, Mr. Lamač outlines his four key contributions to advancing the field, each supported by corresponding scientific publications appended to the thesis. Notably, one of these papers has been published in the prestigious *Physical Review Letters*.

The first paper presents a novel mechanism for X-UV light emission during high-power laser interactions with plasma mirrors. Using advanced theoretical models and kinetic plasma simulations, Mr. Lamač identified this previously unrecognized mechanism, which can produce high-yield X-UV emissions along the surface of the plasma mirror at grazing incidence. His work demonstrates that this mechanism can achieve efficiency at the percent level, enabling the production of bright X-UV pulses. In the near term, this discovery is expected to drive new experimental efforts aimed at measuring this X-UV emission.

In his second paper, Mr. Lamač explores innovative methods to create relativistic mirrors for generating bright X-ray pulses. He proposed a novel technique involving a relativistic electron beam passing through an underdense plasma to drive a plasma wave. This wave, comprising electrons moving at relativistic speeds that can act as a moving mirror, allowing for the production of bright X-ray attosecond pulses via Doppler temporal compression and frequency upconversion. Mr. Lamač's simulations demonstrate that this method could potentially match the brightness of traditional X-FEL sources, offering an alternative approach to compact X-ray generation.

The third paper presents a creative approach to enhance the efficiency of betatron X-ray sources from laser wakefield accelerators. By extracting a small portion of the laser pulse energy to generate 2ω and 3ω

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components, which interact resonantly with electrons accelerated in the laser's wake, Mr. Lamač showed that photon flux can be significantly increased. If successfully implemented in experiments, this advancement could have important implications for single-shot X-ray radiography or spectroscopy applications using this source.

In his final paper, Mr. Lamač investigates the generation of intense magnetic fields in plasmas, demonstrating that giga-Gauss level magnetic fields can be produced when a high-power laser interacts with plasma. His analytical models and 3D simulations reveal that these fields are long-lived and tunable, providing a novel platform for laboratory astrophysics experiments.

In summary, I am deeply impressed by the quality, originality, and depth of Mr. Lamač's work. His ability to tackle complex physical problems with creativity and rigor is evident throughout the thesis. Without hesitation, I strongly endorse this thesis as meeting the highest standards for a PhD degree in physics.

Yours sincerely,

Henri VINCENTI

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