Report on PhD thesis of Petr Valenta

I have read the PhD thesis of Petr Valenta along with the publications resulting from the thesis results. The thesis is an excellent combination of theory and simulation that addresses state-of-the-art issues of high interest in the field of intense laser interaction with underdense plasmas, mainly connected with laser wakefield acceleration (LWFA). Overall, the stated goals of the thesis are met.

The technical background section of the thesis is very well written and complete, and demonstrates the candidate's deep understanding of the relevant physics and techniques. These include the laser-plasma interaction physics and the introduction to the particle-in-cell method. These thesis sections are of the high quality one looks for as reading material for the next generation of graduate students new to the field.

As for the original results, the thesis first discusses the development of ring electromagnetic structures and wakefield-accelerated electrons. The analytical and computational treatment is extensive and through, accompanied by very good physical insight. As I am an experimentalist doing directly related research, this is much appreciated. The thesis then discusses the polarity reversal of laser-driven wakefields under the condition of carrier-envelope phase slip in plasmas, which is especially acute in near-critical density plasmas. This is another phenomenon central to experimental research I am doing, and I found the calculations, simulations, and physical explanations exceptionally informative. The work on relativistic mirrors is an interesting exploration of how one might use the sharp walls of a laser-excited bubble (as one commonly generates in LWFA) to upshift the frequency content of a counter-propagating probe pulse, which may include high harmonics generated at the interface. The first of these papers explores the reflection of the counter-propagating pulse in 1D geometry, examining the effect of increasing probe intensity on the plasma mirror, which is called a "recoil" effect. The second uses PIC simulations to look at the more realistic situation of oblique reflection from the rippled bubble cavity wall. These results constitute very interesting as well as practical physics: One can envision these results as providing the basis for a potential optical diagnostic method for examining wakefields.

In summary, I assess this thesis as excellent, and I recommend that it be presented for defense.

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