Detection of electromagnetic pulses produced by intense laser-matter interaction from parabola modulations in Thomson Spectrometry

B. Grau[1,2,3], F. Filippi[2,3], M. Scisciò[2,3], E. Domenicone[4,2], M. Cipriani[2,3], M. Alonzo[2,3], P.L. Andreoli[2], G. Cristofari[2], E. Di Ferdinando[2], S. Agarwal[5,6], P. Gajdoš[7], M. Krupka[5,7], S. Mirabella[8,9], G. Morello[10,11,12], M. Nocente[4], F. Odorici[13], G. Pasquali[14,15], G. Petringa[16], R. Rinaldi[10,17], S. Singh[5,7,18], A. Trifirò[9,19], G.A.P Cirrone[16,20], C. Verona[1,3], and F. Consoli[2,3]

[1]*University of "Tor Vergata", Rome, Italy*

[2]*ENEA – Nuclear Department, C.R.Frascati, Frascati, Italy*

[3]*INFN-Section of "Tor Vergata", Rome, Italy*

[4] *Department of Physics "G. Occhialini", University of Milano-Bicocca, Milan, Italy*

[5]*Institute of Physics, Czech Academy of Sciences, Prague, Czech Republic*

[6]*Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic*

[7]*Institute of Plasma Physics, Czech Academy of Sciences, Prague, Czech Republic*

[8]*Department of Physics and Astronomy, University of Catania, Catania, Italy*

[9]*INFN – Section of Catania, Catania, Italy*

[10]*INFN – Section of Lecce, Italy*

[11]*CNR IMM – Institute for Microelectronics and Microsystems – University of Lecce, Via per Monteroni, 73100, Lecce, Italy*

[12]*Center of Biomolecular Nanotechnologies, University of Lecce, Istituto Italiano di Technologia, Via Barsanti, I – 73010, Arnesano (LE), Italy*

[13]*INFN – Section of Bologna, University of Bologna, Bologna, Italy*

[14]*INFN – Section of Milan, Milan, Italy*

[15]*Department of Physics and Astronomy, University of Florence, 50019 Sesto Fiorentino, Italy*

[16]*INFN-Laboratori Nazionali del Sud, Via S.Sofia 62, Catania, Italy*

[17]*University of Lecce, Lecce, Italy*

[18]*Faculty of Electrical Engineering, Czech Technical University in Prague, Czech Republic*

[19]*Department MIFT, University of Messina, Messina, Italy*

[20]*Centro Siciliano di Fisica Nucleare e Struttura Della Materia, Catania, Italy*

When a high-intensity laser interacts with matter, it creates a plasma, thus emitting particles and generating strong electromagnetic (EM) radiation. We focus for this study on the emitted EM fields ranging from MHz to THz, known as electromagnetic pulses (EMPs). These EMPs, originating from various sources in laser-matter interactions [1], can reach peak intensities of the MV/m order, posing risks to electronic devices, spoiling the measurements, and being harmful to individuals. The study of EMPs is then of primary importance in laser-matter experiment to know how to mitigates them. However, they also proved their interest in many applications such as medicine, defense, and aerospace.

Various detectors are typically employed for EMP characterization [2]; this work investigates the possibility of using Thomson Spectrometry which is a commonly used diagnostic in many laser-matter experiment, as an alternative diagnostic tool. This device detects and differentiates laser-accelerated ions, according to their charge-to-mass ratio, via combined electrostatic and magnetostatic fields, producing characteristic parabolic traces on the detector. However, under the influence of EMPs, the particles that enter the spectrometer deviate from their ideal trajectory, producing modulations and ripples on the detected signals, which encode information on the transient electromagnetic fields.

We present an analysis of such EMP-induced distortions, observed during an experiment of high-power laser-plasma interaction, performed with a kJ-class laser at the Prague Asterix Laser System (PALS). This experiment gives a unique opportunity to correlate the spectral deformation of ion parabolas with EMP activity inside the interaction chamber.

Previous investigations mainly focused on EMP-induced distortions of proton signals [3], in this work, we extend the methodology to heavier ions, whose parabolic traces carry complementary information on the EMPs strength. The analysis highlights similarities in the modulations shape and amplitude between proton-associated distortions and those affecting heavier ion traces.

These results demonstrate that the Thomson Spectrometer, traditionally employed for ion diagnostics, can also serve for EMP characterization.

References

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