Vectorial electro-optic measurements of intense radiofrequency-microwave electromagnetic pulses in regimes relevant to inertial confinement fusion

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Laser-plasma interaction commonly generates transient radiofrequency-microwave electromagnetic pulses (EMPs) with bandwidths of several GHz and duration up to hundreds of nanoseconds. They are observed for laser-pulse duration from nanoseconds to femtoseconds, with associated electric fields up to the MV/m. For this reason they produce in many cases saturation and even damage to the electronic equipment within and nearby the experimental chamber. It is of primary importance to improve knowledge on EMPs for dealing with these problems on present and future plants for inertial-confinement-fusion and laser-plasma acceleration (NIF, LMJ, PETAL, ELI, Apollon…). Moreover, EMPs can supply information on the related laser-plasma interaction and their characterization can become an effective diagnostic tool.

Measurements of EMPs due to laser-plasma traditionally present many difficulties with usual metallic probes, heavily suffering from effects due to ionizing radiation generated in laser-matter interaction. Moreover, they give only access to one component of the field in a given position and only in terms of time-derivative. For this reason we proposed an innovative method for the measurement of the EMP electric fields in nanosecond laser-plasma interaction by means of the linear electro-optic (Pockels) effect on crystals [1], which has been recently applied successfully to the petawatt regime on experiments with Vulcan picosecond laser [2].

Here we describe the simultaneous vectorial measurements of intense EMP fields by Pockels effect in experiments relevant to inertial confinement fusion, performed with nanosecond laser at intensities ~10^{14}-10^{15} W/cm^2, for λ = 1054 nm. Measurements and related particle-in-cell simulations indicate that signals match the emission of charged particles detected in the same experiment, and suggests that anisotropic particle emission from target, X-ray photoionization and charge implantation on surfaces exposed to plasma, could be important EMP contributions.[a]

References

[1] F. Consoli, R. De Angelis et al, Scientific Reports 6, 27889, 2016.
[2] T.S. Robinson, F. Consoli et al, to be published on Scientific Reports.

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