Superintense laser-driven particle sources for the elemental analysis of materials

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In this contribution, the potential of laser-driven radiation sources for the non-destructive elemental characterization of materials is discussed.

Analytical techniques based on charged particle-induced X-ray emission spectroscopy (EDX, PIXE), neutrons (NAA) and photons (PAA) are well recognized as major tools in materials science. Despite their exceptional capabilities, the further developments of these techniques have been prevented for several decades by the limits of the adopted particle sources.

Because of their potential compactness and versatility, laser-driven radiation sources may represent a promising alternative to conventional accelerators. In addition, they offer the possibility of generating different kinds radiation with minor variations in the setup. Therefore, laser-driven particles could play a pivotal role in several materials science applications [1].

Here we present a comprehensive experimental and theoretical investigation aimed at performing a combined laser-driven Energy Dispersive X-ray spectroscopy and quantitative laser-driven Particle Induced X-ray Emission analysis [2]. The experiment was carried out at the Centro de Láseres Pulsados (CLPU) in Salamanca with the 200 TW VEGA-2 laser. We consider a case study of particular interest, i.e. the analysis of a non-homogeneous sample (i.e. a micrometric surface layer and a thick substrate).

We also show the results of theoretical investigations focused on other applications like the Neutron Activation Analysis and the Photon Activation Analysis techniques [3]. By combining analytical modelling, Particle-In-Cell and Monte Carlo simulations, we show that the use of advanced double-layer targets and suitable Lithium and Tungsten converters can allow to exploit the laser-driven protons and electrons for the generation of neutrons and photons required by NAA and PAA, respectively.

These results pave the way toward the development of laser-based particle acceleration platforms for multiple materials science studies.

References

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[3] F. Mirani, et al., arXiv preprint arXiv:2104.07513 (2021).