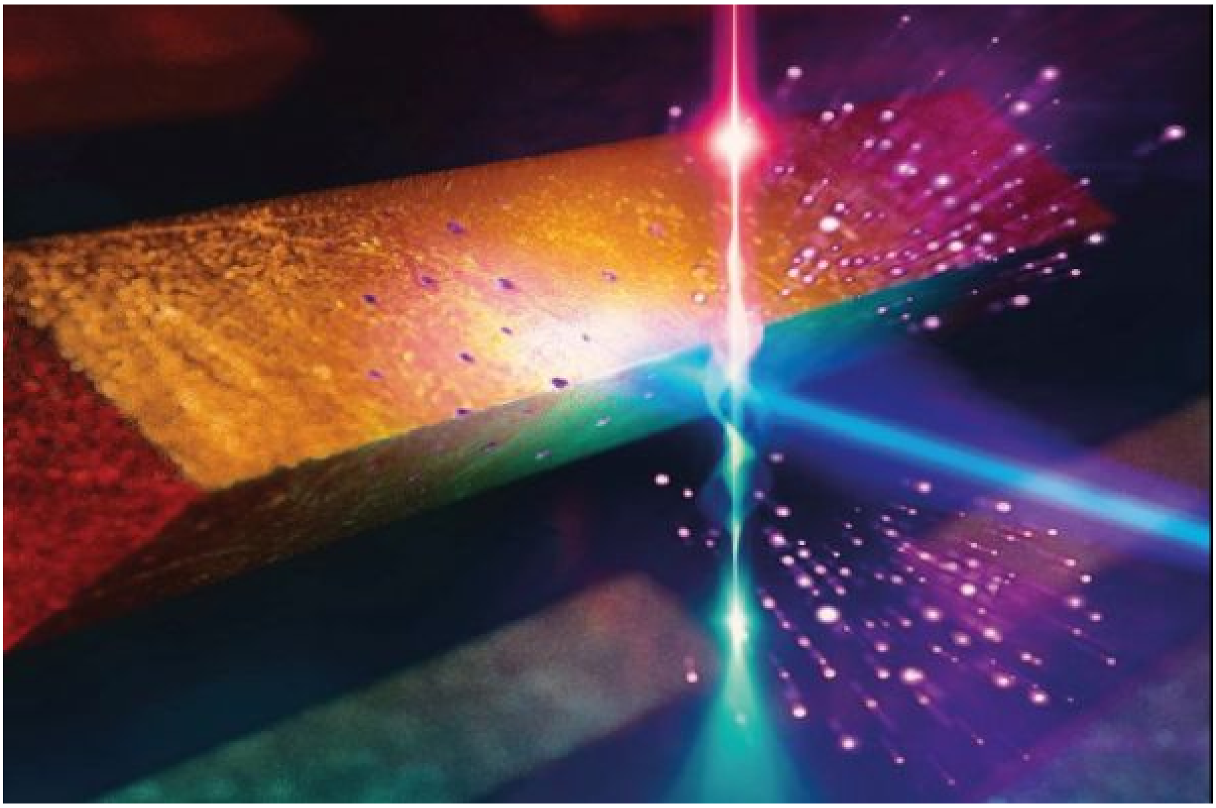

Analyzing ultra-fast dynamics of nano structure surfaces with intense light and electron plasmas

An international team of researchers develops the theoretical framework to understand and control the generation of Terahertz radiation in the vicinity of a metal surface.

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The radiation of light in the Terahertz (THz) range, a region of the electromagnetic spectrum that is in between microwaves and infrared light, has recently attracted significant attention because of its manifold applications, especially those related to the control and manipulation of nanostructured materials.

It's amazing potential for spectroscopy, sensing, imaging, or communication technologies has catapulted it as a potential tool for understanding light-matter interactions because it has the ability to penetrate through optically opaque materials, and study its interior thanks to it high sensitivity to chemical composition.?

However, the efficient generation of THz light remains a challenge, and even more so whe aiming for nanoscale sources and ultra-fast phenomena. The current methods used to creat this intense light in this range is based on nonlinear optical phenomena that use nonlinea crystals are, in fact, very inefficient.

? In a recent study published in **Nanoscale Advances**, and selected to appear on the cover of the journal, ICFO researchers **Eduardo Dias** and **ICREA Prof. at ICFO Javier Garcia de Abajo**, in collaboration with researchers from Ecole Polytechnique Federale de Lausanne, University of Geneva, Israel Institute of Technology, and University of Milano-Bicoca have developed a comprehensive microscopic theory for understanding and describing the spatial, temporal, and spectral characteristics of the generation of intense Terahertz (THz) fields on a metallic surface through the use of laser-pulse-induced electron plasmas.

Electron plasmas have proven to be a useful alternative source of the generation of THz light. They can be extracted by illuminating very intense laser sources on metal surfaces, which creates a cloud of electrons or electron plasma characterized by its dense volume. The dynamics of these electrons, whether they remain in the vicinity and then are reabsorbed by the metal or escape away from the surface, is what helps understand the structural nature of these material surfaces.

The researchers carried out a thorough theoretical analysis of the spatiotemporal dynamics of the electron plasma created from the illumination of an infrared laser-pulse source (l=800nm) on a metal wedge. They specifically studied and presented a theoretical framework that showed how the electron plasma was generated due to the illumination of the laser-pulse on the metallic surface, and how, under different conditions, this plasma evolved and behaved. The evolution and behavior of the plasma was monitored by an electron probe that analyzed the electron plasma dynamics and the generation of the THz light radiation. They took electron beam pulses, defined different scenarios of trajectories for the electron and for each trajectorial scenario, they studied the interaction of the electron with the plasma for trajectories that depend on the angle of approach to the metallic surface and the distance from it.

The resulting work of this study enables new approaches and insights on the generation and dynamics of electron plasmas close to metallic surfaces, and permits advancements in important applications such as sensing, spectroscopy, imaging, and in particular for understanding and describing ultrafast dynamics of complex nanoscale systems, through the use of ultrafast electron microscopes.