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IPFN researchers Nuno Lemos and João Mendanha Dias (right) used the world's most intense laser to create the brightest gamma ray beam ever generated in a laboratory environment - an achievement that opens up new perspectives for applications in medicine such as cancer treatment and medical imaging.

The work was done in collaboration with colleagues from the University of Strathclyde and the Rutherford Appleton Laboratory (both UK), using the Astra-Gemini laser facility. The results were published this week in Nature Physics.

In comparative terms, this gamma ray source has an equivalent brightness over a thousand billion that emitted by the sun. Its unique features, such as high spatial coherence, high brightness and ultra-short duration can open up new paths in a number of applications such as biology, materials science, nuclear physics, environmental safety and medicine.

The principle used to create the gamma ray beam is based on the concept of laser-plasma acceleration, a technique in which the IPFN team has been working for several years. When charged particles such as electrons are accelerated, they emit radiation. In this experiment, electrons are trapped in the ion cavity trailing behind a very intense laser pulse that propagated through a plasma. Once there, they are accelerated to high energies, reaching velocities close to the speed of light.

These electrons are further accelerated once they reach and interact with the laser pulse, beginning to oscillate strongly. The oscillatory motion of highly energetic electrons allows is the principle behind increasing the energy of emitted radiation up to the gamma rays.

This so called laser-plasma accelerators, which are based on high-power laser pulses propagating in plasmas, are able to accelerate charged particles to very high energies in very short lengths. In fact, it could be possible to reduce dramatically the size of conventional accelerators, from hundreds of meters to a few centimeters.

The GoLP/IPFN duo teamed up with researchers from the University of Strathclyde to perform the breakthrough experiment using the Astra-Gemini Laser - currently one of the most intense of the World, at 10^22 Watts per square centimeter. Such extreme values are achieved by concentrating a very high energy in an extremely short duration - a fraction of a billionth of a second. Such laser pulses have unique features that allow, for example, studying the matter at the scale of the atomic nucleus.

"Reaching for the first time the resonance regime of the accelerated electrons with the field of laser pulse has enabled us to go from the ultra-bright x-ray region up to the gamma rays", says N. Lemos. According to João Mendanha Dias, "these new, compact and economical gamma radiation sources, will allow a wider democratization of their applications, so far only possible in large scale facilities such as conventional particle accelerators."

Ultra-bright gamma ray sources allow probing dense matter, for instance when checking the integrity of stored nuclear waste. In addition, their ultra-short duration allows the study of ultrafast phenomena in the structure of matter at the nuclear scale.