# **Gamma Factory, or how the largest accelerator facility is bringing atomic physics to its extreme**

Szymon Pustelny (for the Gamma Factory collaboration)  
Marian Smoluchowski Institute of Physics, Jagiellonian University in Kraków  
Łojasiewicza 11, 30-348 Kraków, Poland   
e-mail:pustelny@uj.edu.pl

Modern accelerators represent one of the most spectacular examples of the success of the human intellect over matter. The development of accelerator systems over the past decades has led to many important discoveries, with the last one being the discovery of the God particle - the Higgs boson. Paradoxically, this great discovery put high-energy physics in a crisis, as none of the existing high-energy physics theories provides predictions that could be confirmed with the available, or even envisioned accelerators. This poses an inevitable question about the legitimacy of the existence of accelerator facilities but also stimulates searches of novel applications ranging far beyond their current framework.

While high-energy physics seems to be on the defensive, atomic physics on the other hand has enjoyed enormous successes over recent years. New, more and more precise experiments not only provide knowledge about the surrounding Universe and its laws, but also offer tools that are used in other branches of physics, as well as astronomy, chemistry, biology, archeology, medicine, etc. However, even that does not change the fact that atomic physics must also face specific challenges. For instance, numerous quantum phenomena could be better studied and possibly understood if it was possible to interact with electrons of the inner electron shells of heavy atoms. Unfortunately, due to large energy gaps between energy levels of the strongly-bounded electrons, until now, such studies have been extremely difficult due to the lack of available light sources.

During the talk, I will present a new proposal at the interphase at atomic and high-energy physics called Gamma Factory [1]. I will show how these two disciplines may lead to a qualitative change in science, offering yet unavailable research opportunities. Specifically, I will discuss how, based on the interaction of ultrarelativistic strongly ionized heavy ions with laser light, spectroscopy of hydrogen-, helium-, lithium-like lead, at transition energies of hundreds or even thousands eV becomes possible [2]. I will also talk about how such scheme allows to boost photon energies over 10,000,000 times, making the system intense source of megaelectronovolts photos and hence enabling applications in atomic, nuclear and high energy physics, but also in chemistry and biology.

REFERENCES

[1] W. Placzek *et al.*, Acta Phys. Pol. B 50, 1191 (2019).  
[2] J. Bieroń, M. W. Krasny, W. Płaczek, and S. Pustelny, arXiv:2106.00330.  
[3] D. Budker *et al.*, Ann. Phys. (Berlin), 532, 2000204 (2020).