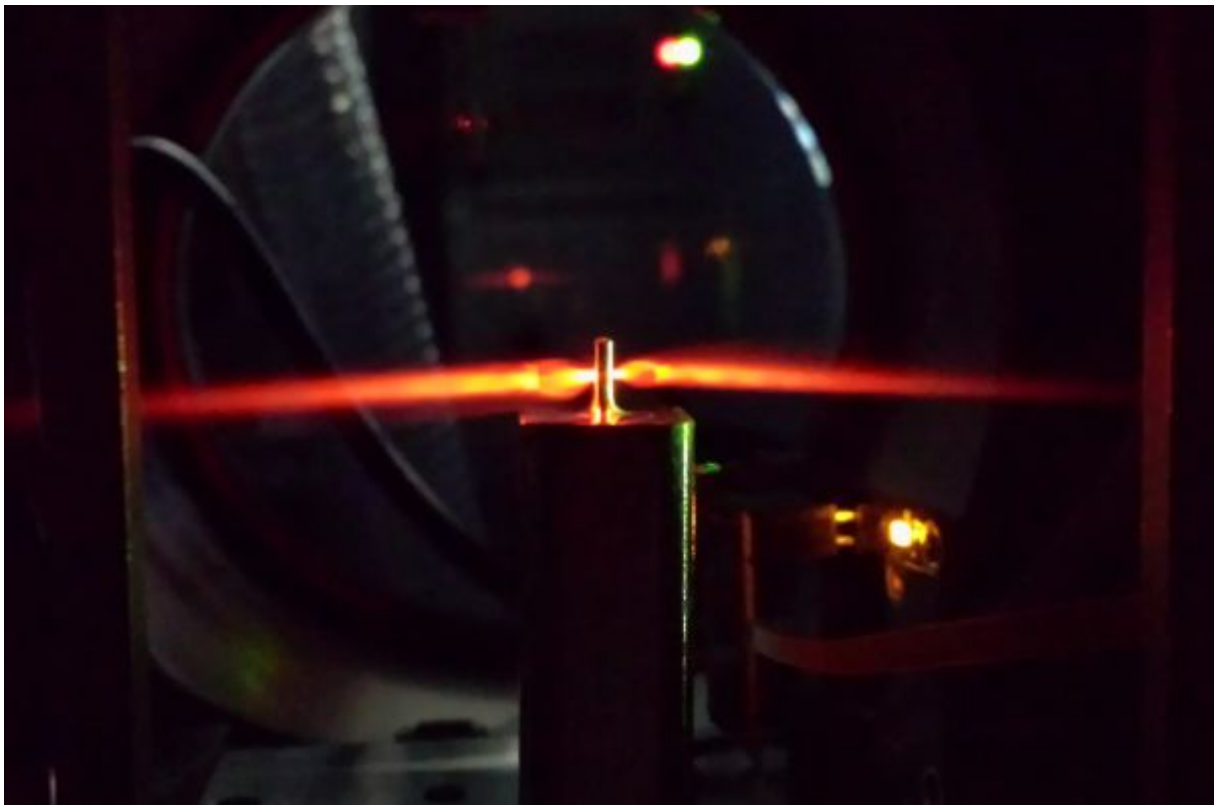


Breaking barriers in attoscience with the shortest light pulse ever created

ICFO researchers have set a new record by generating the shortest soft X-ray pulse to date -just 19.2 attoseconds long. This is the fastest flash of light, faster than the atomic unit of time (24.2 attoseconds), which is the time it takes the electron to orbit once around the hydrogen atom - the i¿½atomic yeari¿½. This enable it to capture how matter behaves and interacts at atomic and subatomic scales with unprecedented temporal resolution.

December 17, 2025

Electrons determine everything: how chemical reactions unfold, how materials conduct electricity, how biological molecules transfer energy, and how quantum technologies operate. But electron dynamics happens on attosecond timescales-far too fast for conventional measurement tools.

Researchers have now generated a 19.2-attosecond soft X-ray pulse, which effectively creates a **camera capable of capturing these elusive dynamics in real time with unprecedented detail**, enabling the observation of processes never observed before. **Dr.**

Fernando Ardana-Lamas, **Dr. Seth L. Cousin**, **Juliette Lignieres**, and **ICREA Prof. Jens Biegert, at ICFO**, have published this new record in Ultrafast Science. At just **19.2 attoseconds** long, it is **the shortest and brightest soft X-ray pulse** ever produced, giving rise to the fastest ?camera' in existence.

Flashes of light in the soft X-ray spectral range provide fingerprinting identification, allowing scientists to track how electrons reorganize around specific atoms during reactions or phase transitions. Generating an isolated pulse this short, required innovations in high-harmonic generation, advanced laser engineering, and attosecond metrology. Together, these developments allow researchers to observe electron dynamics, which define material properties, at their natural timescales.

The journey towards this milestone, however, began in 2015, when Prof. Jens Biegert's team pioneered the generation of attosecond pulses in the soft X-ray regime by successfully isolating attosecond bursts of this light. These pulses demonstrated their breakthrough utility by resolving the interaction of electrons with the crystal lattice in a solid and by elucidating how and when a molecular ring opens as a precursor to processes such as polymerization. But, at that time, the method for pinpointing the duration had limitations that could now be overcome, leading to the demonstration of the shortest pulse ever measured.

i¿½When I came to the group and saw the striking traces, I had to look into this with a n w pulse retrieval method,i¿½ shares enthusiastically the first author, Dr. Fern ndo Ardana-Lamas. i¿½Finally, we can say that, to the best of our knowledge, we have con irmed the shortest pulse of light in the wor d!i¿½ i¿½This new capability paves the way for breakthroughs in physics, chemistry, bi logy, and quantum science, enabling direct observation of processes that drive phot voltaics, catalysis, correlated materials, and emerging quantum devicesi¿½ explains Pr f. Biegert, reflecting on the future of attosecond soft X-ray pulses below the atomic unit of time. As he puts it, now that the foundations are laid, i¿½the sky is

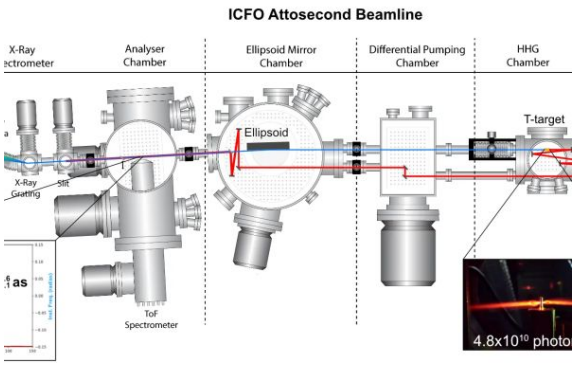
References:

[1] Fernando Ardana-Lamas, Seth L. Cousin, Juliette Ligneres, Jens Biegert. Brilliant source of 19.2 attosecond soft X-ray pulses below the atomic unit of time. Ultrafast Sci. 0:
DOI: 10.34133/ultrafastscience.0128

Acknowledgements:

J.B. and group acknowledges financial support from the European Research Council forERC Advanced Grant i¿½TRANSFORMERi¿½ (788218), ERC Proof of Concept G ant i¿½miniXi¿½(840010), FET-OPEN i¿½PETAComi¿½ (829153), FET-OPEN i¿ ?OPTOlogici¿½ (899794), FET-OPENi¿½TwistedNanoi¿½ (101046424), MINE O for Plan Nacional PID2024-162757NB-I00; QU-ATTO,101168628; AGAUR for 2021 S

R 01449, MINECO for i¿½Severo Ochoai¿½ (CEX2019-000910-S),Fundacio Cel
ex Barcelona, the CERCA Programme/Generalitat de Catalunya, and the Alexander von Hum
oldt Foundation for the Friedrich Wilhelm Bessel Prize. JB also acknowledges Lasers4EU
which is funded by the European Union funds under HEU-GA 101131771.



Schematic layout of the ICFO experimental set-up used to generate, condition, and analyze attosecond X-ray pulses. The diagram traces the propagation of the driving infrared laser beam (red) and the soft x-ray beam (blue).

