PHYSIKALISCHES KOLLOQUIUM

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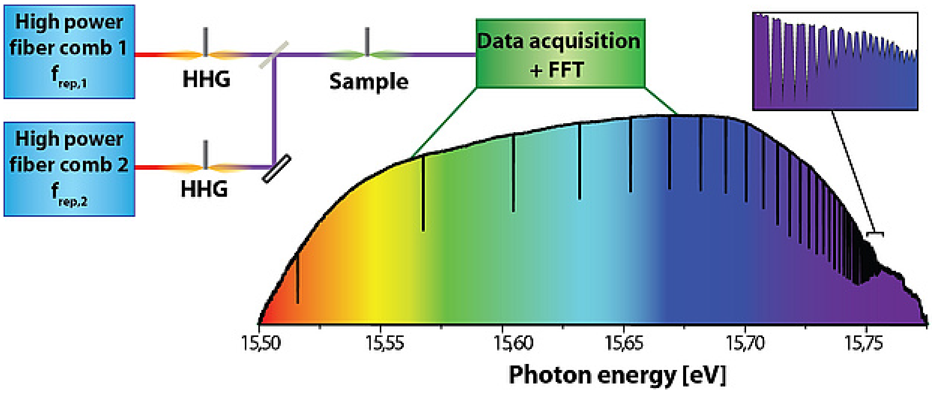

DUAL COMB SPECTROSCOPY – ACHIEVING ULTRA-HIGH SPECTRAL RESOLUTION

BIRGITTA BERNHARDT
GRAZ UNIVERSITY OF TECHNOLOGY

Light-matter interactions are central to many areas of physics, enabling us to probe the properties of matter and observe chemical reactions in real time. Many of these processes, especially involving electron dynamics, occur on extremely short time scales—femtoseconds (10-15 s) to attoseconds (10-18 s). To study these ultrafast phenomena, scientists use ultrashort laser pulses that can capture rapid changes with high spectral detail.

A recent exciting development is dual comb spectroscopy, which combines high spectral resolution with rapid measurement capabilities across broad wavelength ranges, including visible, infrared, and terahertz regions. This technique has been successful in molecular spectroscopy and nonlinear imaging like Raman spectroscopy. However, extending it into the ultraviolet and extreme ultraviolet (XUV) regions remains challenging. Our research focuses on generating XUV radiation through nonlinear frequency up-conversion, enabling the study of ultrafast electron dynamics in atoms and molecules. These XUV sources facilitate attosecond pump-probe experiments, allowing us to observe electron motions and ionization processes with unprecedented clarity.

In my talk, I will present the principle behind optical frequency combs—precise pulsed lasers that revolutionized spectroscopy and earned the Nobel Prize in 2005. I will highlight how the Coherent Sensing Group at TU Graz is advancing dual comb spectroscopy including efforts to extend its reach into the ultraviolet via nonlinear methods. Our applications range from environmental sensing in the field to real time spectroscopy in the lab. By combining dual comb spectroscopy with pump-probe techniques, we aim to develop powerful tools for resolving photo-induced processes with exceptional temporal and spectral precision, opening new frontiers in ultrafast science across chemistry, biology, and energy research.

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