Generation of ultrashort and ultrabroadband UV light pulses in nonlinear cystals

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

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Attosecond Science

DESY.

scientific context

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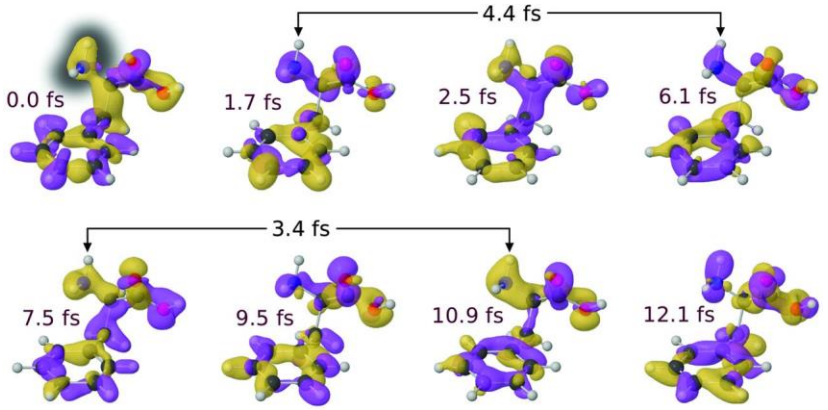
- No laser gain medium in the UV available
- Plethora of phenomena require UV radiation
  - Study of biomolecules
  - Lithography
  - 3D printing

→ Necessity of secondary UV generation



F. Calegari et al., *Ultrafast electron dynamics in phenylalanine initiated by attosecond pulses*.Science 346, 336-339 (2014)

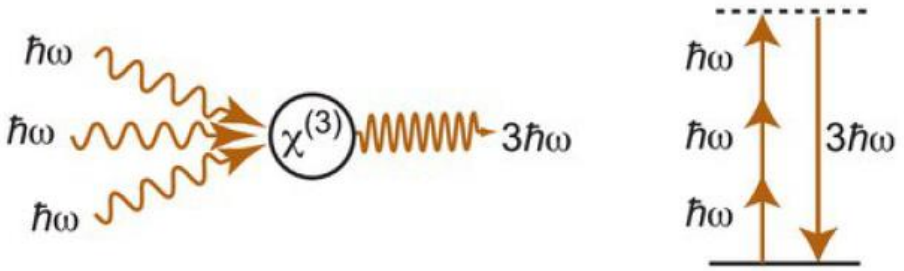
- Study of molecular dynamics requires femtosecond temporal resolution

→ Necessity for ultrashort laser pulses

➔ Ultrashort UV pulses are needed to study dynamics in many biomolecules

aim of the experiment

- Generation of ultrashort UV pulses
- Learning about frequency conversion in nonlinear media

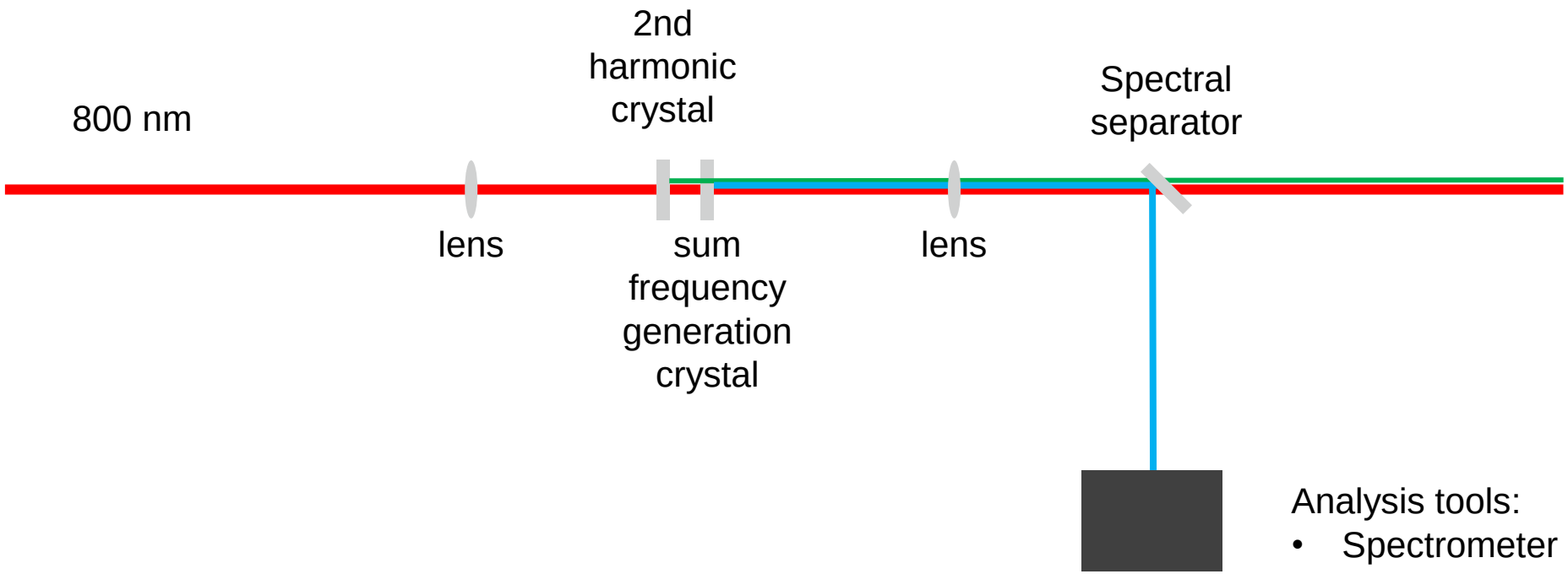


Measurement of:

- Generated spectrum
- Pulse energy → Conversion efficiency (dependant on phase matching angle, input power)
- polarisation

experimental setup

emphasis on challenges and teaching objectives



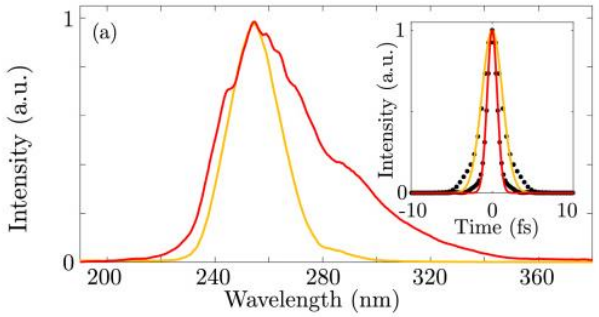
Analysis tools:

- Spectrometer
- Powermeter
- Polarisation analysis

data analysis method

emphasis on tools and teaching objectives

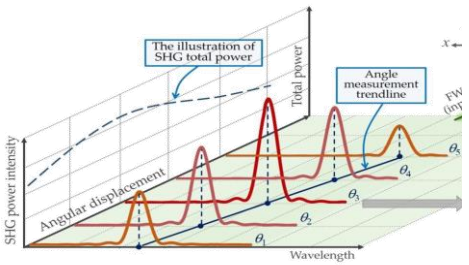
Spectrometer



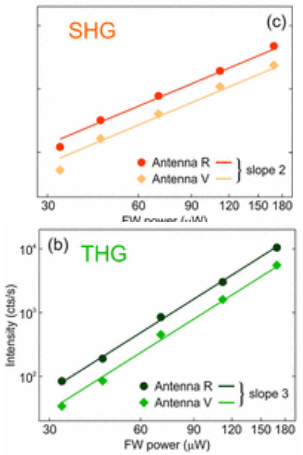
M. Galli *et al.* (2019) Opt. Lett. **44**, 1308-1311

Fourier transform limit

Powermeter



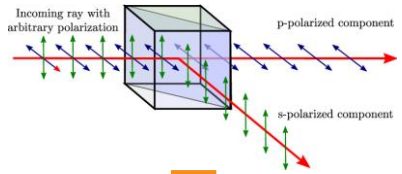
Appl. Sci. **2022**, *12*(10), 5211

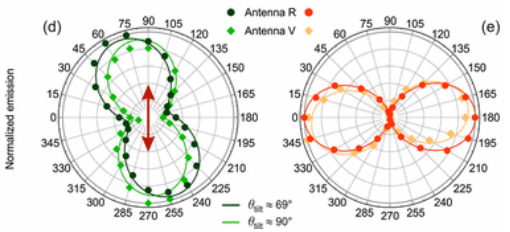


Nano Lett. 2019, **19**, 10, 7013–7020

Calculation of conversion efficiency, Fitting plots, Comparison to literature

Polarisation measurement





Nano Lett. 2019, **19**, 10, 7013–7020

Calculation of standard deviation, Comparison to literature

key scientific results and their relevance

precision compared to state of the art research

- Conversion efficiency of the cascaded THG
  - Relevance: characterization of the nonlinear conversion efficiency of the used crystals
- Polarisation dependence of the generated third harmonic intensity
- Input power dependence of the generated third harmonic intensity
- Transform limit of the generated spectrum, discussion of limitations
  - Relevance: shortest UV pulses possible are desired for state of the art time resolved spectroscopy experiments

link to modern research in the physics department

(if applicable links to clusters of excellence)

- Development of UV light source
  - Efficient frequency conversion (laser industry)
  - Light source development, nonlinear optics (CFEL)
- Pump-probe spectroscopy with UV pump pulses
  - Relevant for study of biomolecules

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B — CAPTURING EMERGENT CHEMISTRY

Research Area B targets molecules of small to medium size which, despite their limited number of atomic constituents, already possess a large number of degrees of freedom. Emergent behaviour in these systems arises through an intimate coupling between the electronic and nuclear sub-systems, and may be further promoted through interaction with a solvent or surface environment.

In this Area the research groups will address the following central questions:

- Which are the key emergent degrees of freedom underlying chemical reactions?
- How can we use light to enforce a desired chemical reaction pathway?
- Can we predict, identify and control new collective states by utilizing strong light-matter coupling? Can we then tailor chemical processes or phase transitions using photons?

In comparison to Area A, the complexity is increased in Area B through the fact that in chemically reactive processes, the atomic positions are not quasi-harmonically confined; translational periodicity is broken. Emergence in chemistry rests on the resulting dynamical interplay of electronic and nuclear motions, which gives rise to collective degrees of freedom that underlie chemical reactions.

In order to identify and characterize the dynamical pathways taken by the key emergent degrees of freedom, we will utilize powerful X-ray and electron scattering and spectroscopy techniques, in close connection with theory. The resulting insights will provide critical clues for the development of effective optical control strategies for steering chemical reactions.

Achieving this dream of steering chemistry will have ramifications for both Areas A and C, where we ultimately aim to gain optical control over processes as diverse as protein conformation and function or competing phases in solids.

Participating research groups:

For more information about each scientist, please follow the individual links on our "Who we are" page.

- Prof. Ch. Bressler
- Dr. Ch. Bömer
- Prof. F. Calegari
- Prof. M. Drescher
- Prof. T. Gorelova
- Prof. T. Herr
- Prof. C. Herrmann
- Prof. F. Kärtner
- Dr. A. Kelly
- Prof. J. Küpper
- Dr. T. Laarmann
- Dr. M. Meyer
- Prof. R. J. D. Miller
- Prof. D. Pfannkuche
- Prof. R. Röhlsberger
- Prof. N. Rohringer
- Prof. A. Rubio
- Dr. M. Ruggenthaler
- Prof. R. Santra
- Prof. A. Stierle
- Prof. M. Thorwart

EXZELLENZCLUSTER
CUI: ADVANCED
IMAGING OF MATTER

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THANK YOU!

http://atto.cfel.de