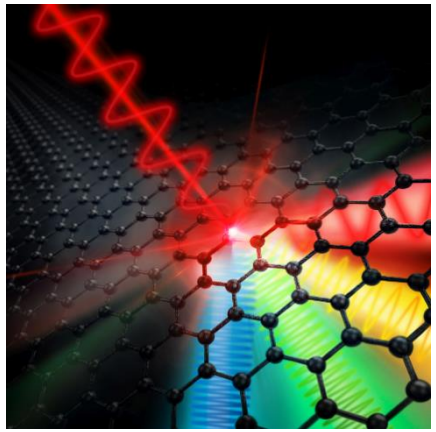
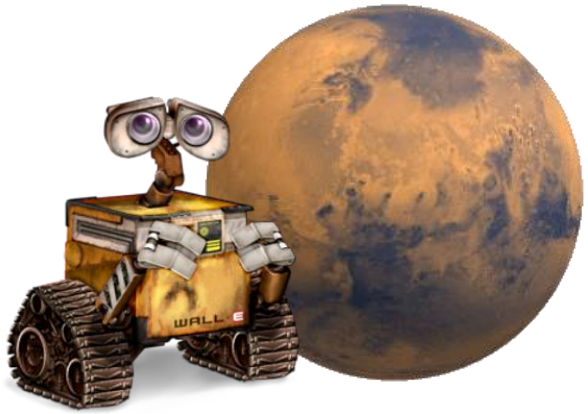
Terahertz and Laser Spectroscopy





Prof. Michael Gensch
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DFG Deutsche Forschungsgemeinschaft

Bundesministerium für Bildung und Forschung

HELMHOLTZ
SPITZENFORSCHUNG FÜR GROSSE HERAUSFORDERUNGEN

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TU berlin

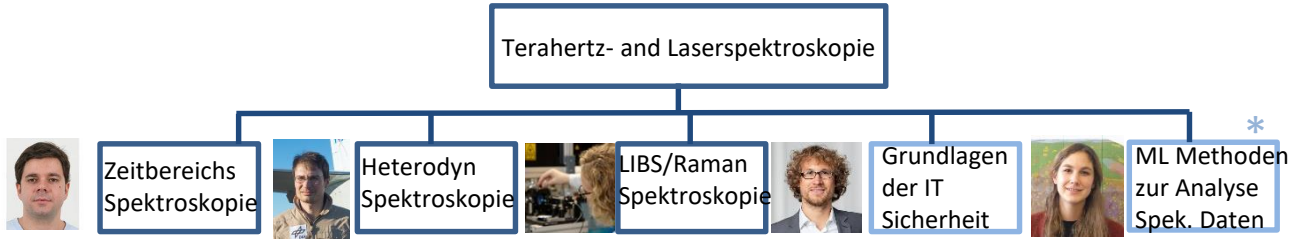
Wo wir sind

Campus TU Berlin

Campus Berlin-Adlershof

Institut für Optik und Atomare Physik
Ernst Ruska Gebäude, ER 144
(wöchentl. Sprechstunde Donnerstags 14:00 – 15:00)
Sekretariat: Frau Reschny

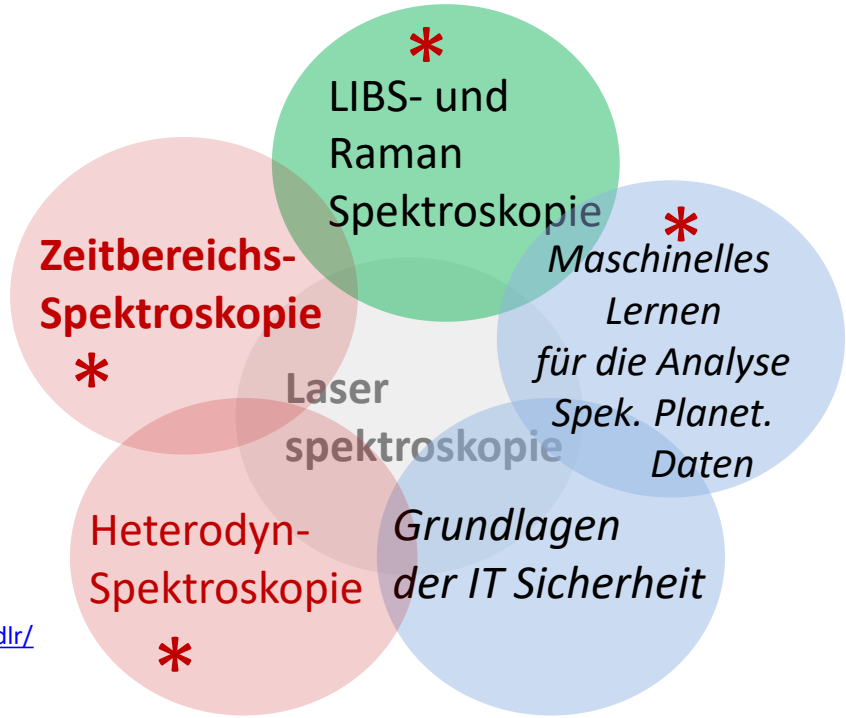
DLR Institut für optische Sensorsysteme
Abteilung Terahertz- und Laserspektroskopie
Rutherfordstr. 2



Was wir tun

„**Entwicklung von (laser-basierten) Spektroskopiemethoden für spezifische Anwendungen in den Materialwissenschaften, der Beschleunigerdiagnostik** oder für den Einsatz auf (robotischen) Missionen zur Erforschung des Weltalls“

Siehe auch:
https://www.ioap.tu-berlin.de/menue/arbeitsgruppen/ag_gensch_tubdlr/ag_gensch_tubdlr/
https://www.dlr.de/os/desktopdefault.aspx/tabid-11921/



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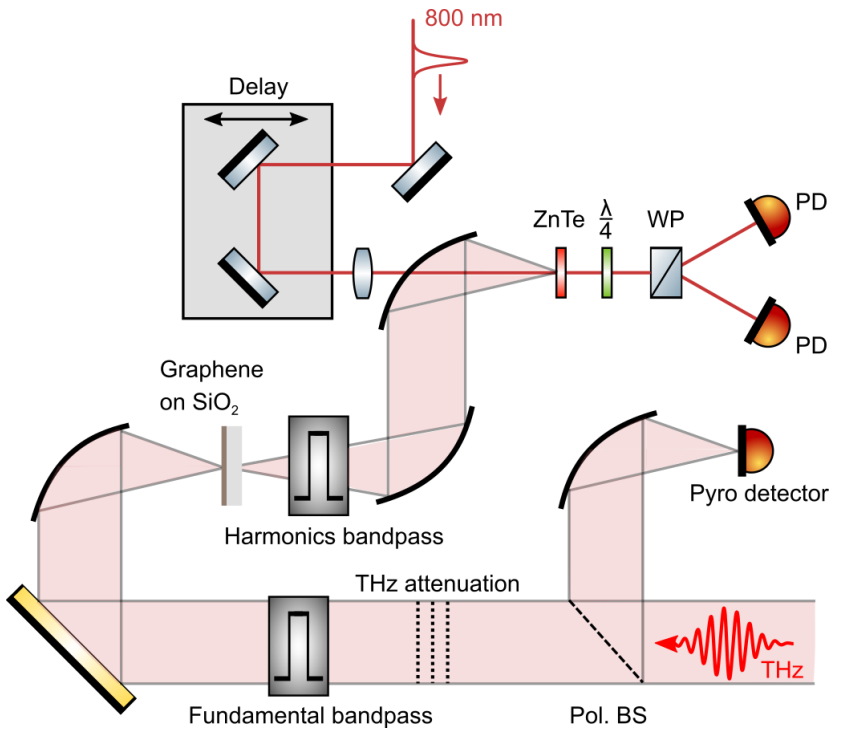
Abteilung Terahertz- und Laserspektroskopie
Rutherfordstr. 2

* arbeiten aktiv auf dem Gebiet der Methodenentwicklung für und Anwendung von Spektroskopie für THz Energieskalen

High-field experiment: nonlinear Terahertz spectroscopy on Dirac materials



LETTER

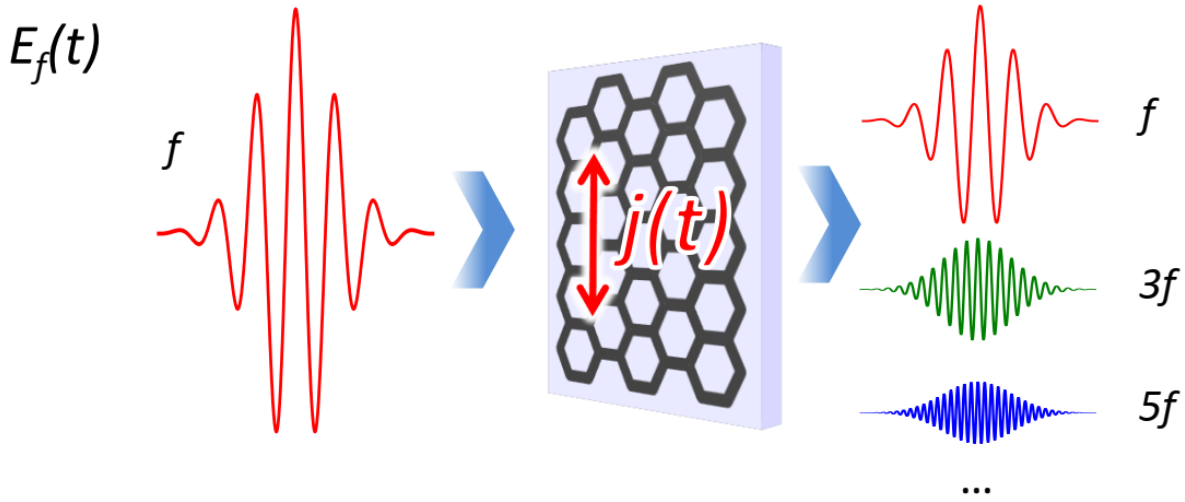
https://doi.org/10.1038/s41586-018-0508-1

Extremely efficient terahertz high-harmonic generation in graphene by hot Dirac fermions

Hassan A. Hafez[1,2,3,7], Sergey Kovalev[4,7], Jan-Christoph Deinert[4], Zoltán Mics[2], Bertram Green[4], Nilesh Awari[4,5], Min Chen[4], Semyon Germanskiy[4], Ulf Lehnert[4], Jochen Teichert[4], Zhe Wang[4], Klaas-Jan Tielrooij[6], Zhaoyang Liu[2], Zongping Chen[2], Akimitsu Narita[2], Klaus Müllen[2], Mischa Bonn[2], Michael Gensch[4]* & Dmitry Turchinovich[1,2]*

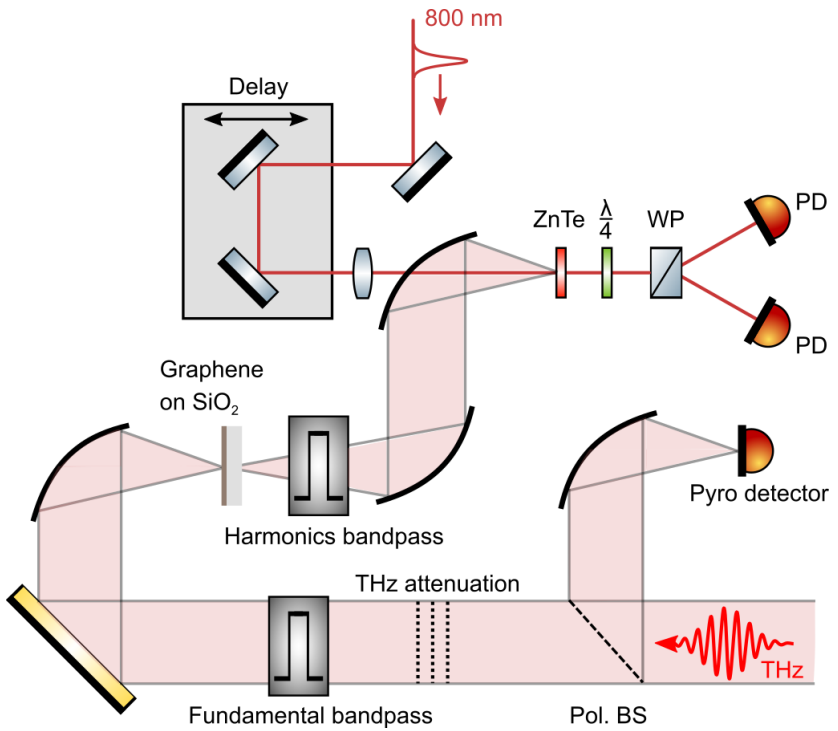
Thermodynamic model

Incident THz field $E_f(t)$ → Electron heating and cooling: ***nonlinear current*** → Re-emitted THz field



Z. Mics et al, Nat. Comm. (2015)

@TELBE – *nonlinear Terahertz spectroscopy*



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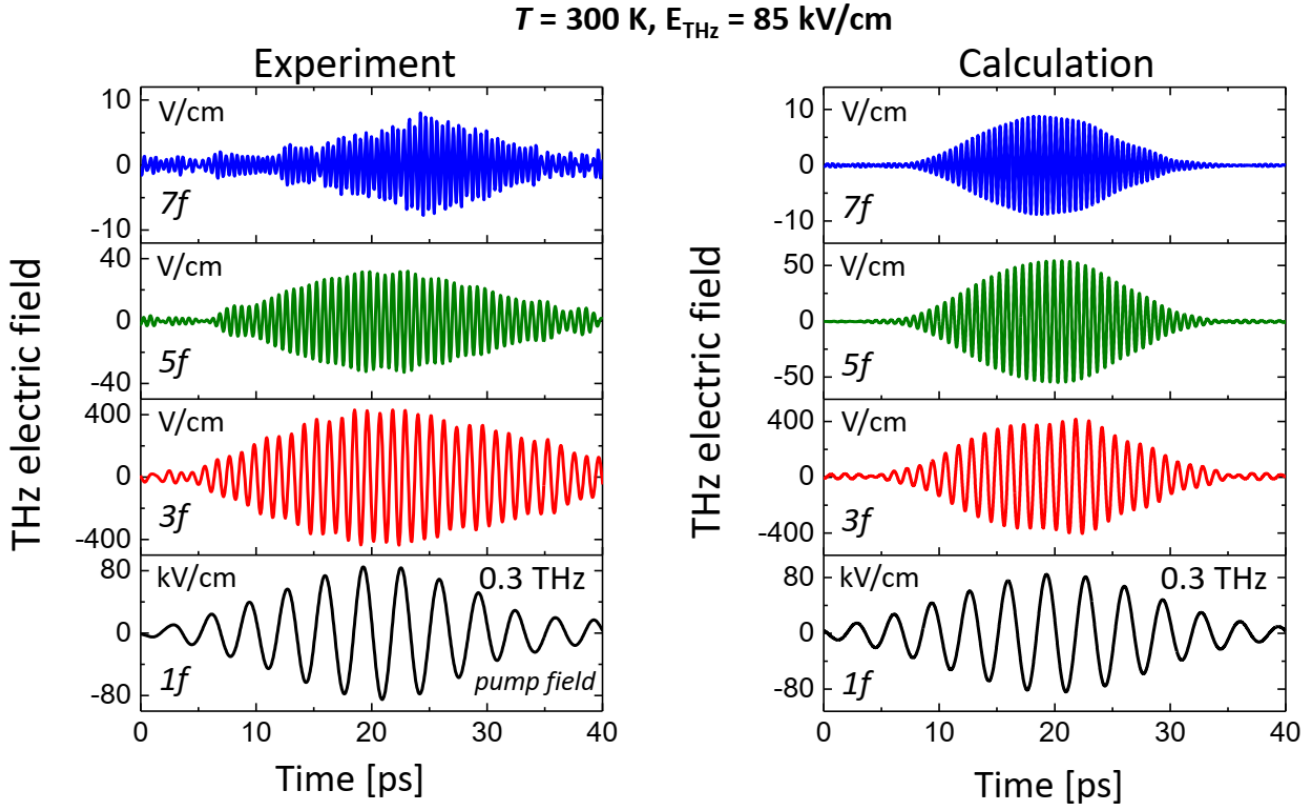

TELBE turned out to be the ideal THz source for this experiment

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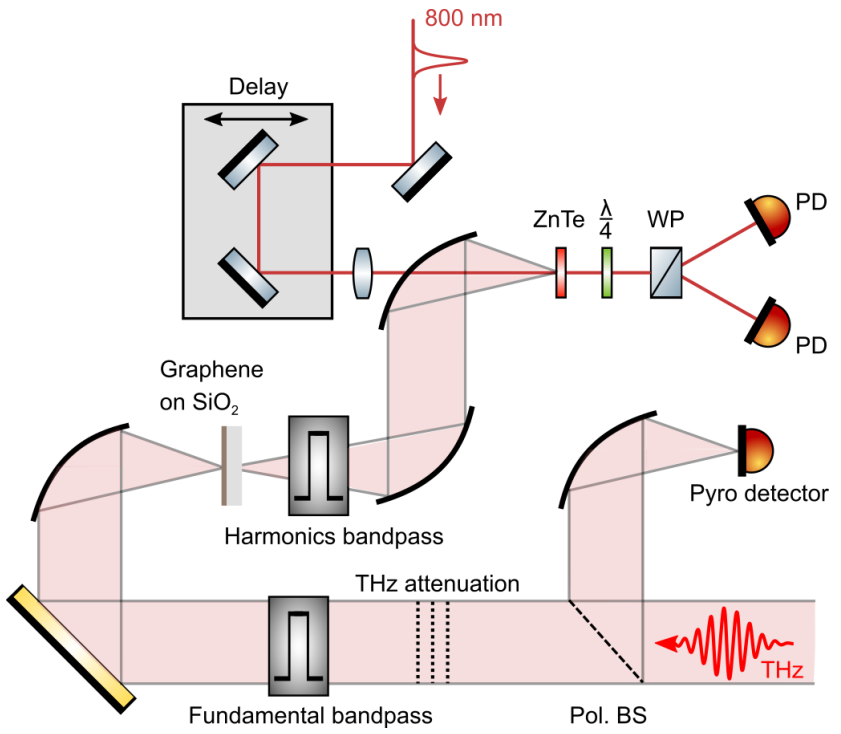
@TELBE – *nonlinear Terahertz spectroscopy*



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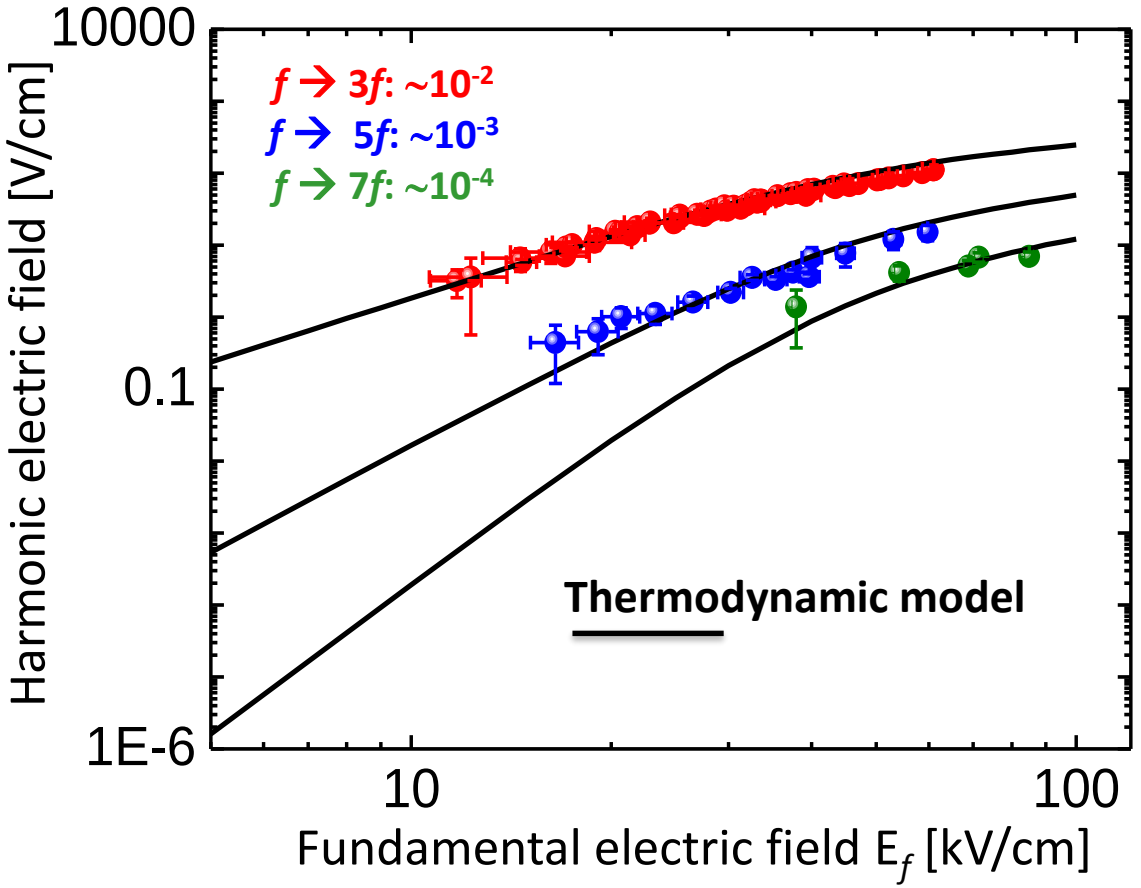
Harmonic field conversion efficiency



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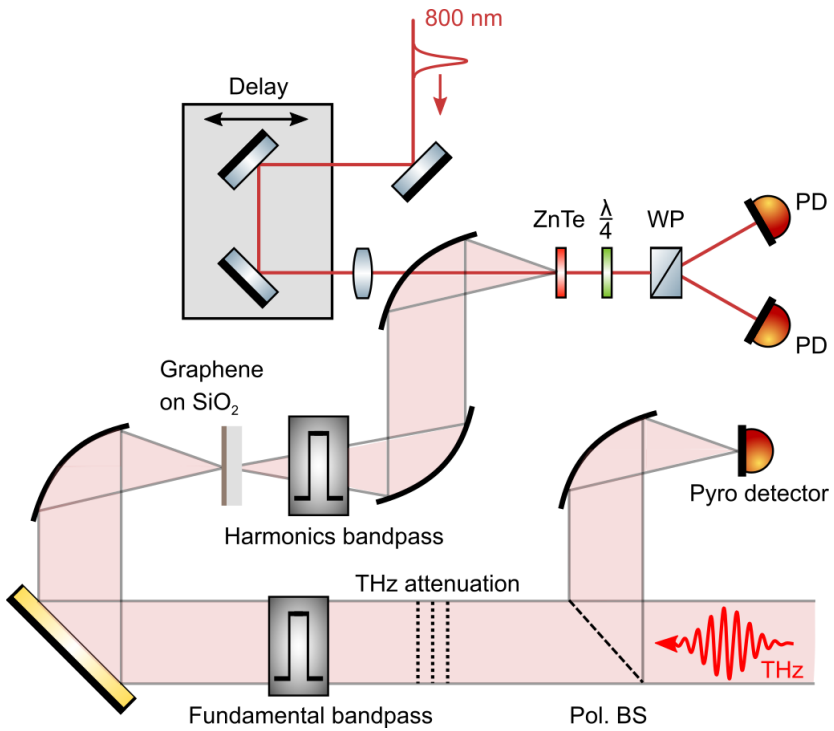
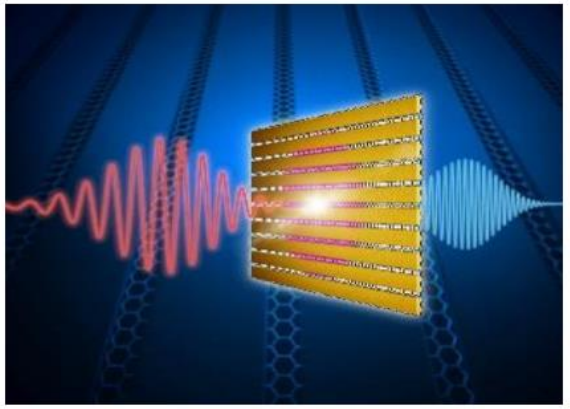
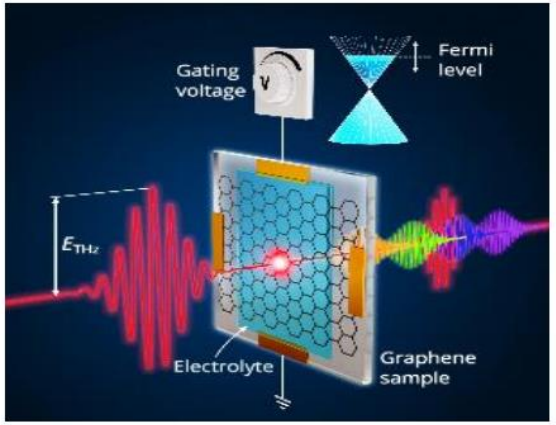
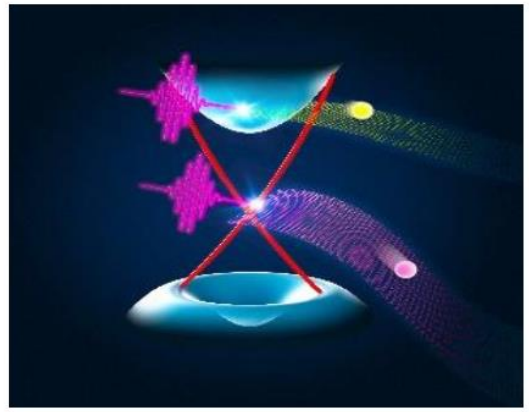




Deinert, J.-C. *et al.*, *ACS Nano* 15, 1145 (2020



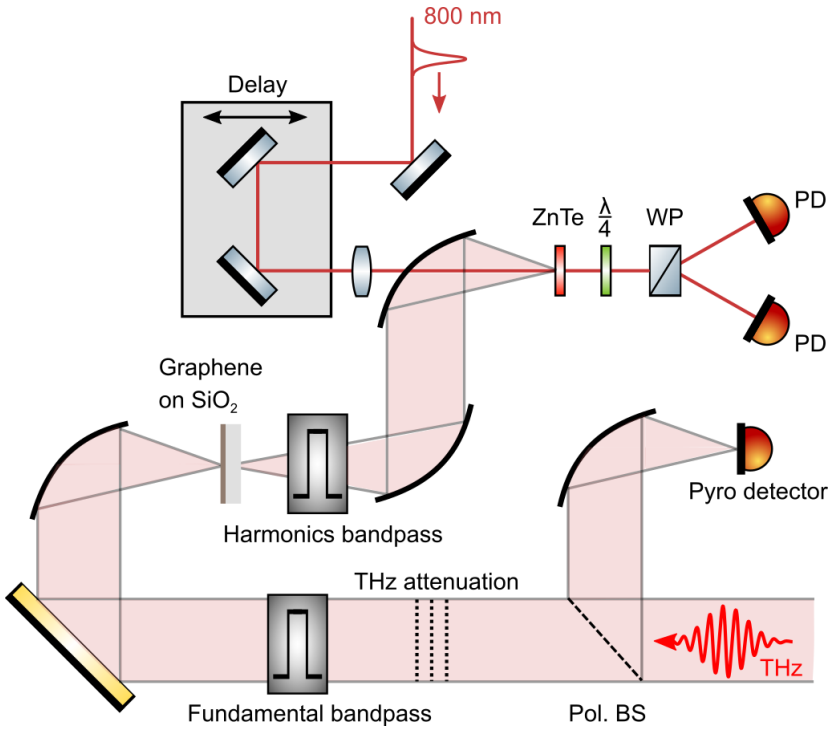
Kovalev, S., Hafez, H. *et al.*, *Science advances* 7, eabf9809 (2021)



Kovalev, S. et al., *npj Quantum Materials* 6, 84 (2021)

TELBE turned out to be the ideal THz source for this type of experiment

Current interest 1: mechanism/efficiencies at shorter wavelengths (50 – 100 μm?)



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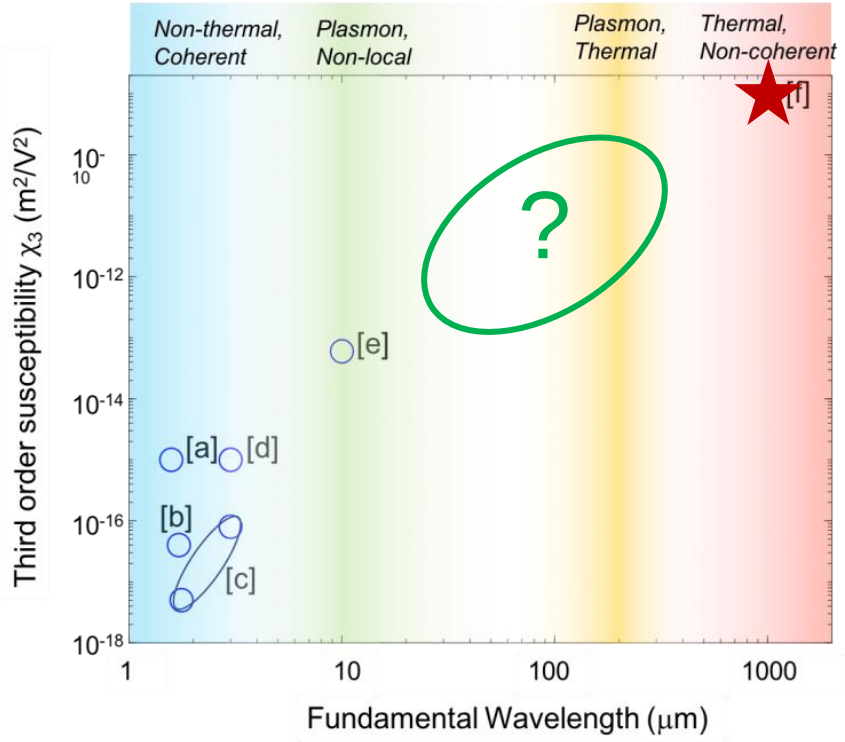

PROGRESS REPORT

ADVANCED OPTICAL MATERIALS

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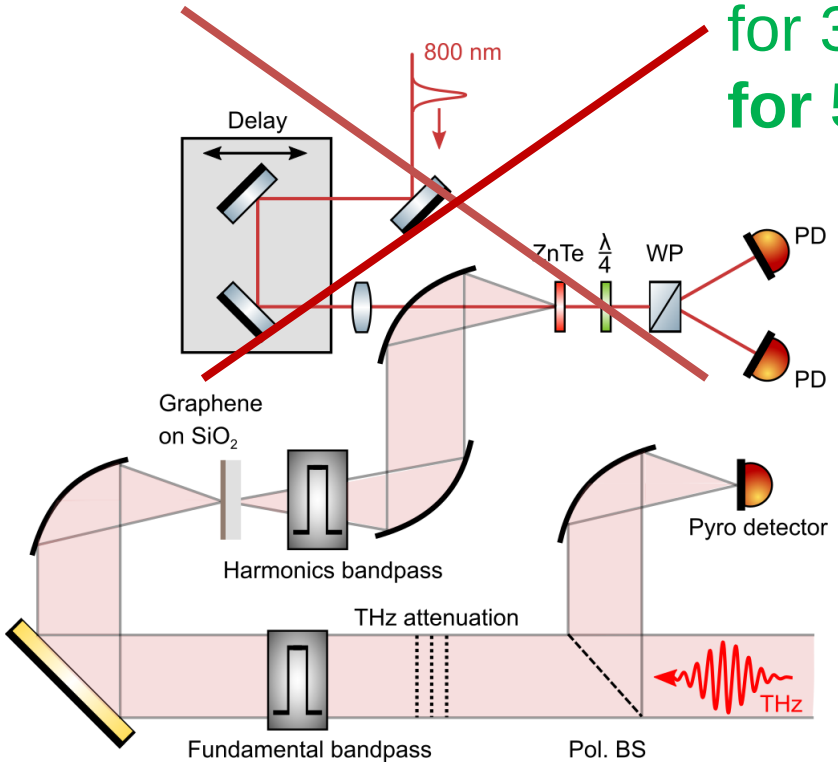
Terahertz Nonlinear Optics of Graphene: From Saturable Absorption to High-Harmonics Generation

*Hassan A. Hafez, Sergey Kovalev, Klaas-Jan Tielrooij, Mischa Bonn, Michael Gensch, and Dmitry Turchinovich**

Current interest 1: mechanism/efficiencies at shorter wavelengths (50 – 100 μm?)

Michelson? IF
for 30 to 100 μm (Pyro)
for 5 to 30 μm (MCT)



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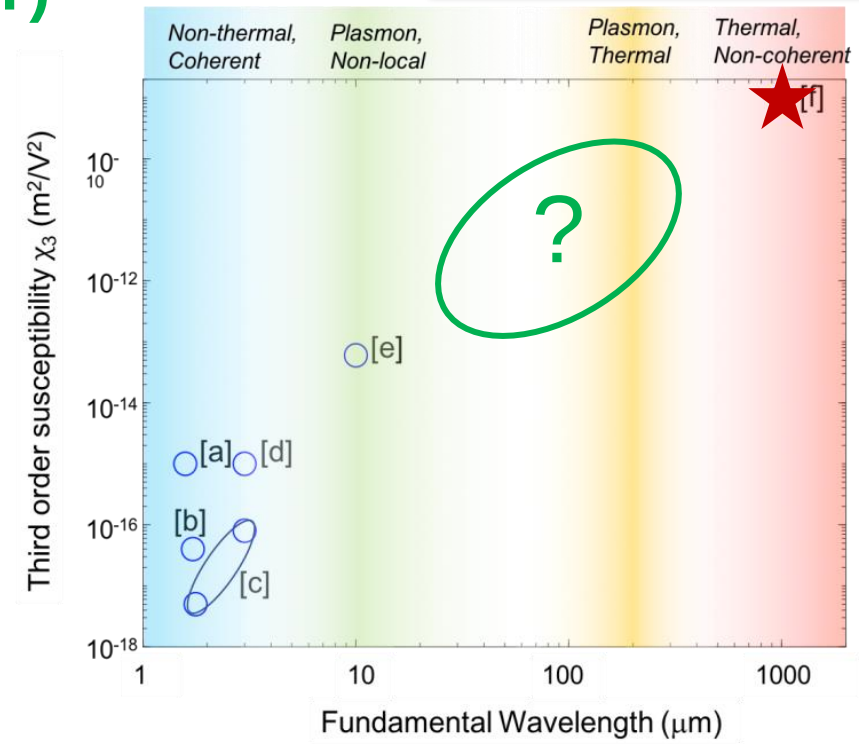

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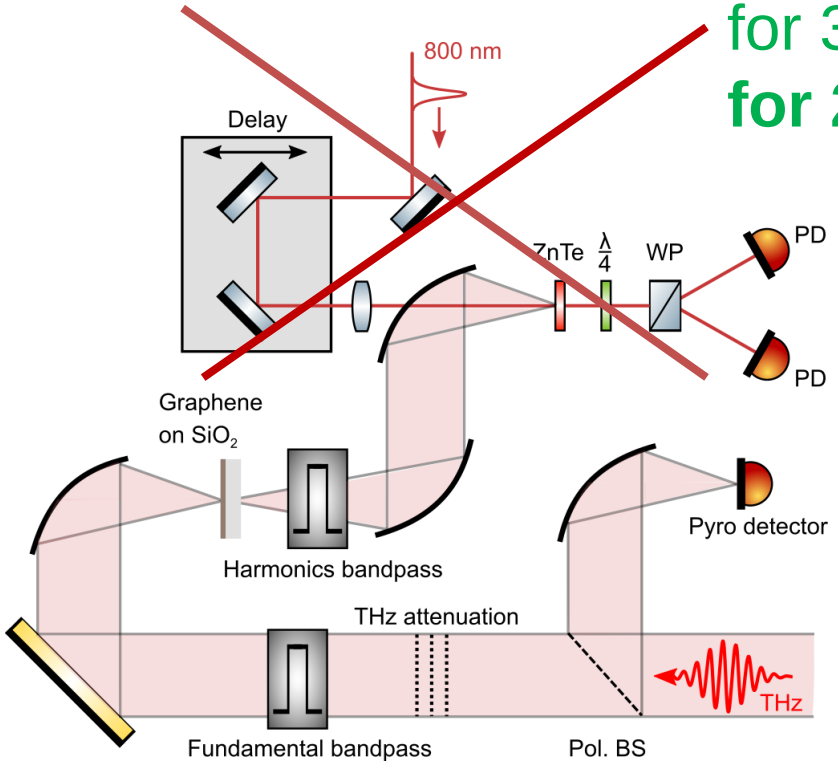
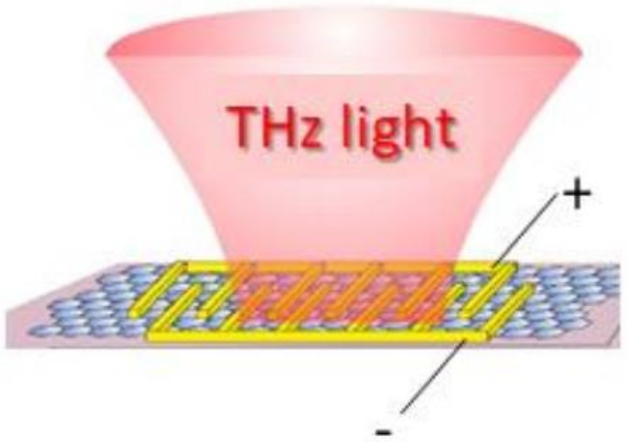
Current interest 2: EFISHG / difference frequency mixing in graphene

Michelson? IF
for 30 to 100 μm (Pyro)
for 25 to 30 μm (MCT)

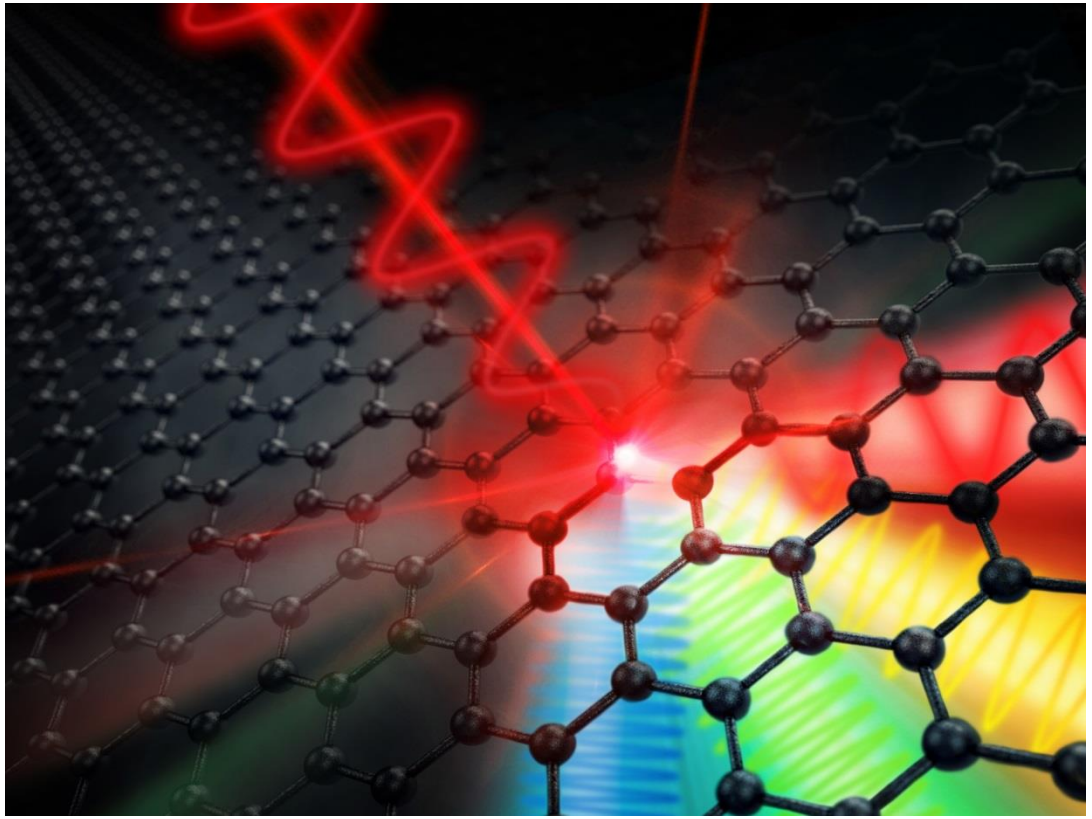


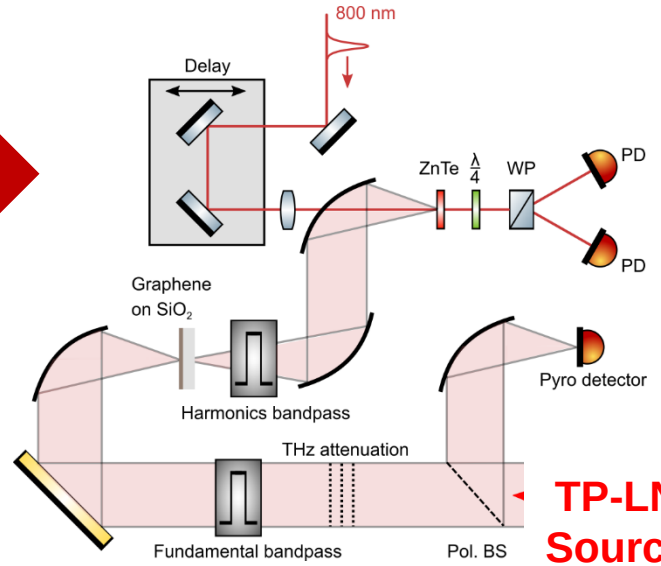


Schematic of patterned graphene device with interdigitated electrodes, to be fabricated at ICN2 (Barcelona, Spain) using photolithography.

like to investigate if an effective 2nd order nonlinearity $\chi^{(2)}$ can be efficiently generated by applying appropriate in-plane DC electric fields, thus breaking the inversion symmetry

Astrella: 800 nm, mJ, few kHz
Opera Solo: 1-20 μJ, few to 500 μJ, 1 kHz
TP-LN: 0.1 – 2 THz, few μJ, few kHz





TP-LN Source *(work in progress)*

Thank you!

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