

Chirality@LOMA:

CHIRAL or NOT CHIRAL ?



université
de BORDEAUX



Thomas BAROIS

KiNOA Day – 29 Sept 2021

Chirality @ LOMA



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Chirality @ LOMA



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Photonics
&
Materials

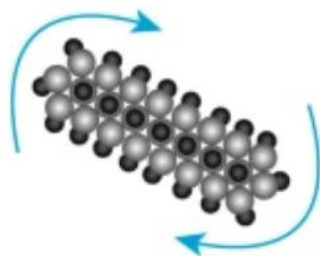
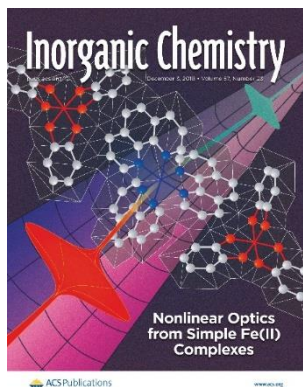
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Theory

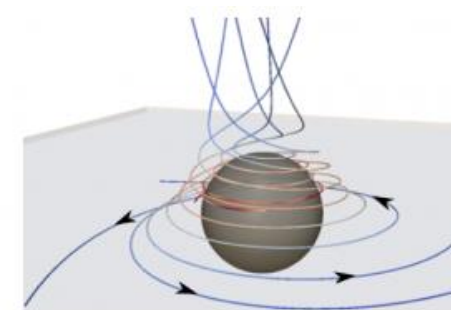
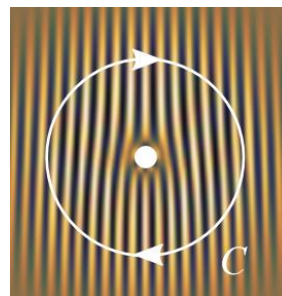
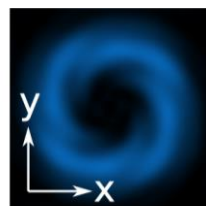
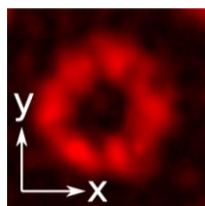
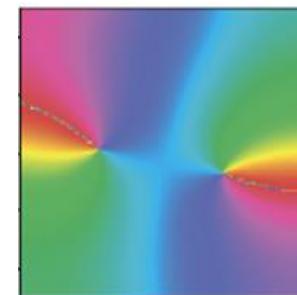
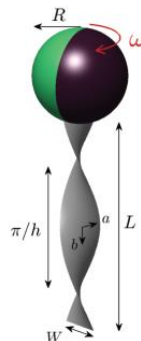
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Soft Matter
& Biophysics

- 29 published papers mention « chiral » in their abstract (Hal, since 2012)
- 24 researchers from LOMA identified chirality as a part of their activity



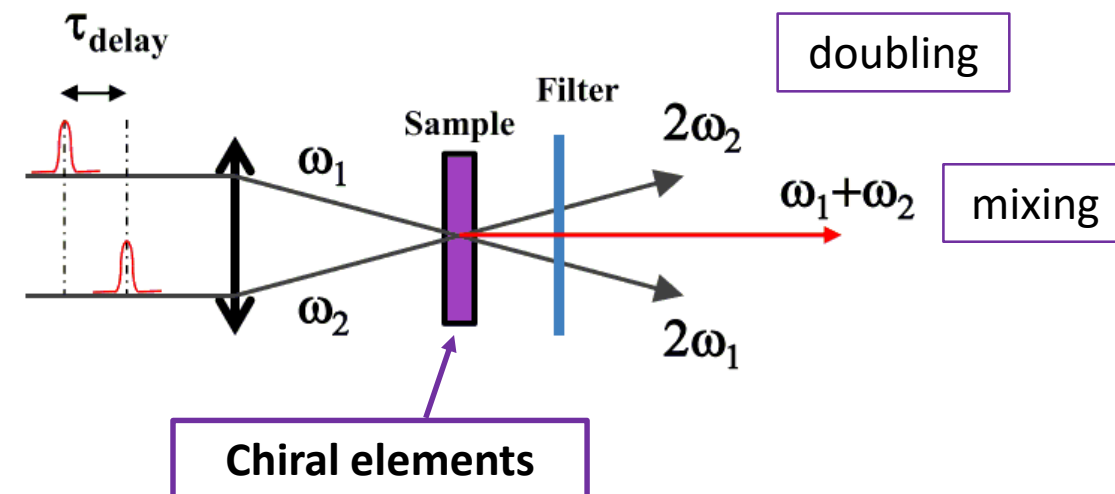
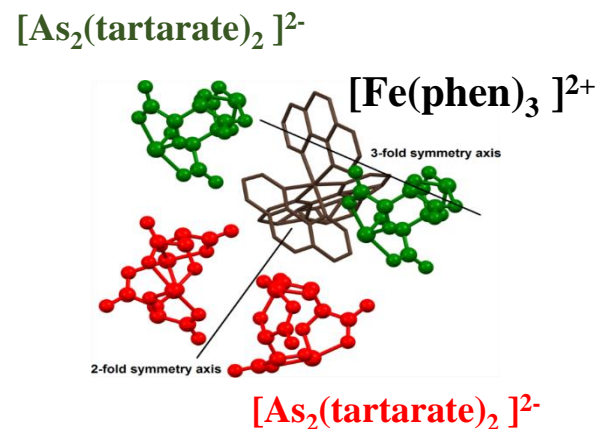
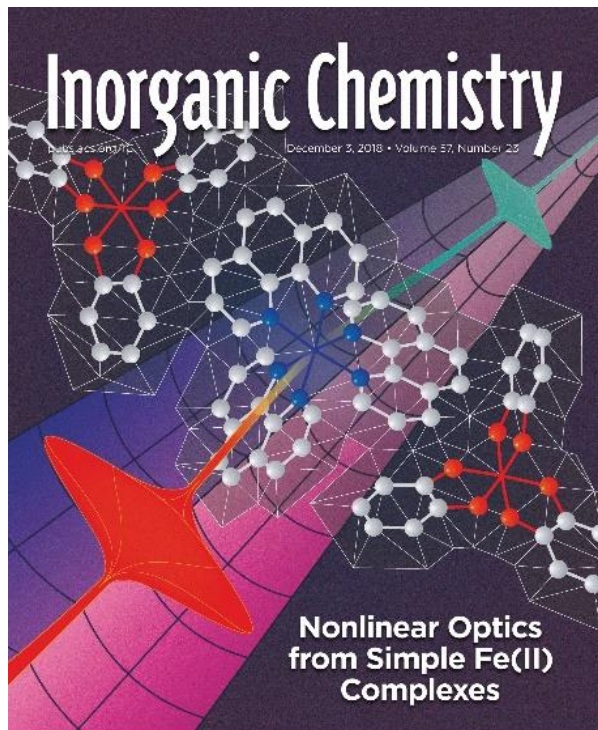
Physics of Fluids



Chirality @ LOMA

I – Geometrical chirality

II – Beyond geometrical chirality



Chiral media : optical activity, second harmonics generation, ...

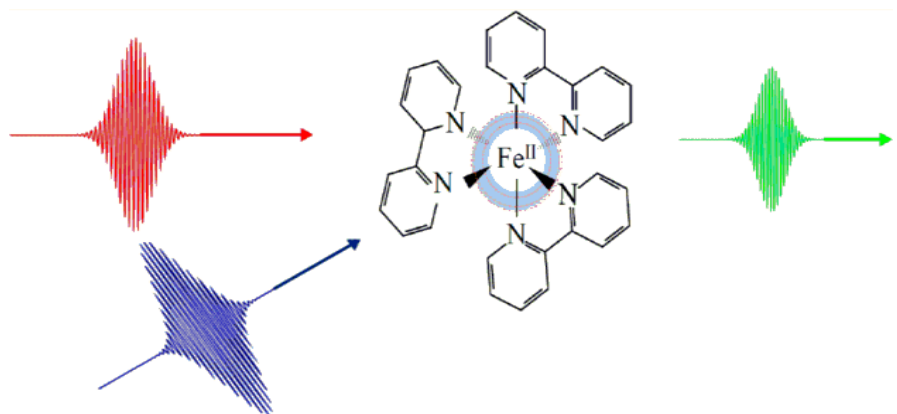
Nonlinear optical properties and application of a chiral and photostimulable iron(II) compound

A. Iazzolino, A. Ould Hamouda, A. Naïm, O. Stefańczyk, P. Rosa, and E. Freysz - *App. Phys. Lett.* 2017

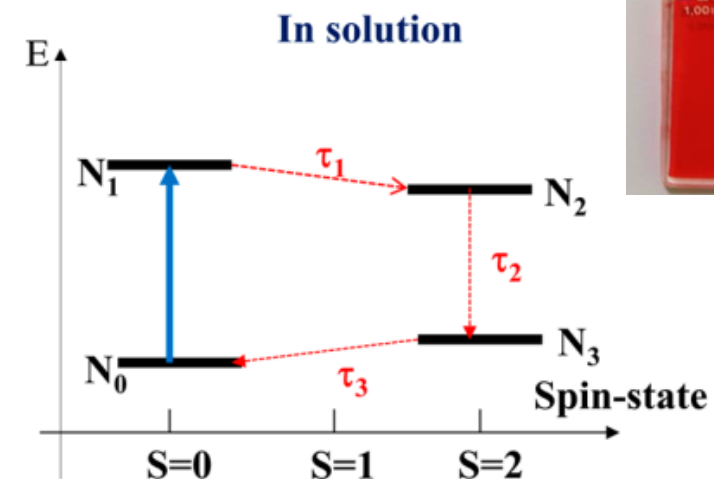
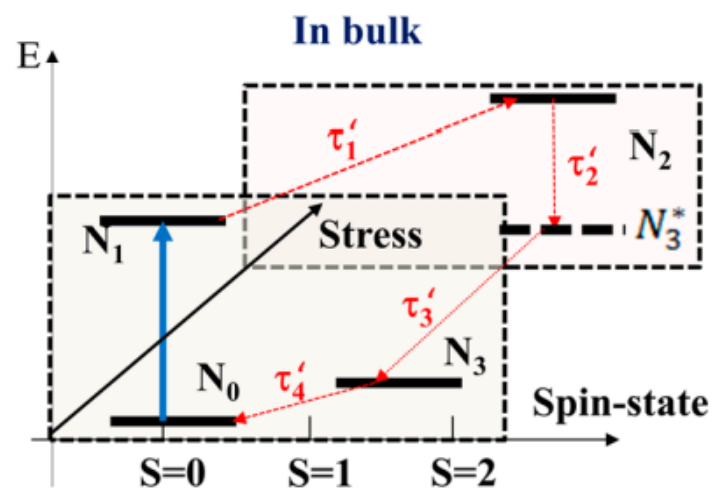
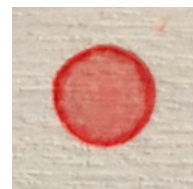
Design and study of structural linear and nonlinear optical properties of Chiral $[\text{Fe}(\text{phen})_3]^{2+}$ complexes

A. Naim, Y. Bouhadja, M. Cortijo, E. Duverger-Nédellec, H.D. Flack, E. Freysz, P. Guionneau, A. Iazzolino, A. Ould Hamouda, P. Rosa, O. Stefańczyk, Á. Valentín-Pérez, and M. Zegga - *Inorg. Chem.* 2018

Ultrafast spectroscopy



Picosecond pulses
(THz regime)

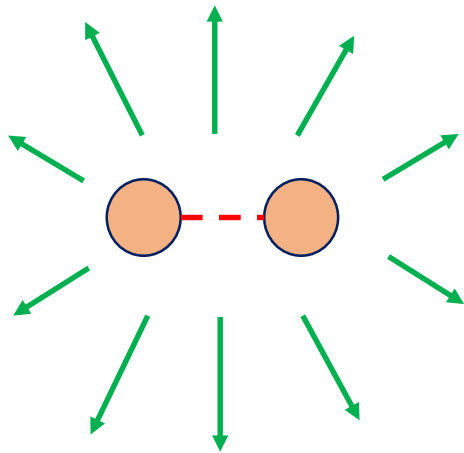


Goal: nonlinear optics in solution

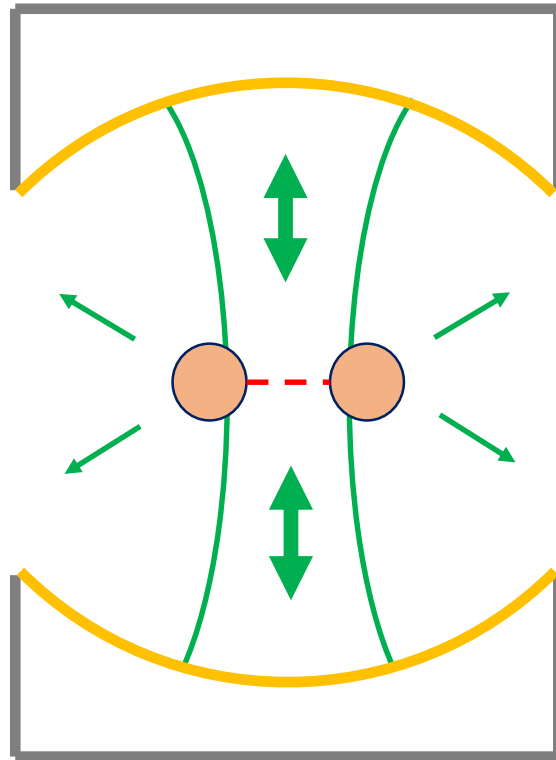
Study of the Photoswitching of a Fe(II) Chiral Complex through Linear and Nonlinear Ultrafast Spectroscopy

A. Ould Hamouda, F. Dutin, J. Degert, M. Tondusson, A. Naim, P. Rosa, and E. Freysz - *J. Phys. Chem. Lett.* 2019

Chemical reaction
with **light** emission:



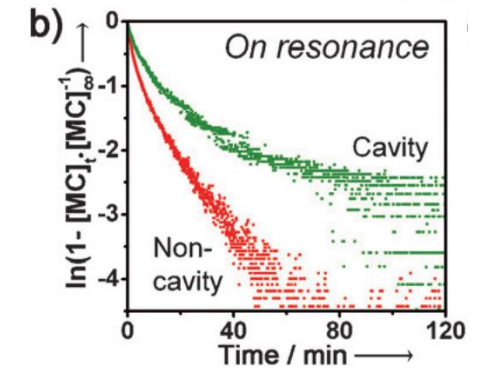
No cavity



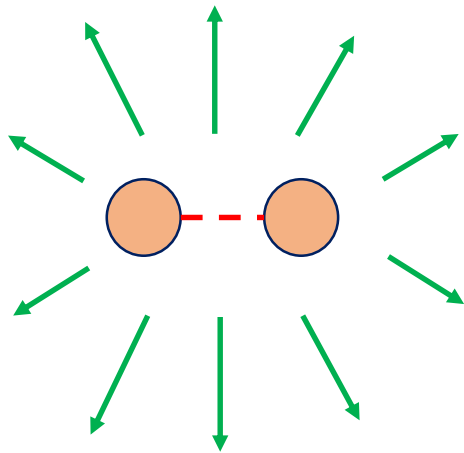
Cavity

Reaction rate

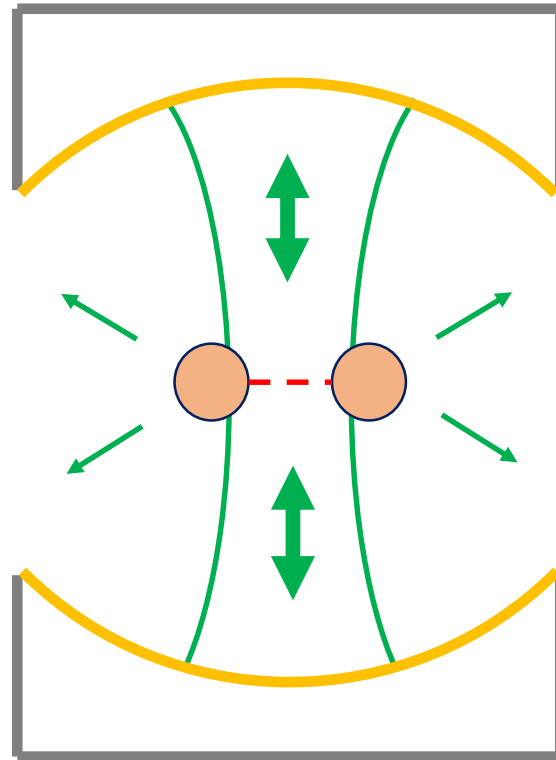
J. A. Hutchison et al.,
Angewandte Chemie (2012).



Chemical reaction
with **light** emission:



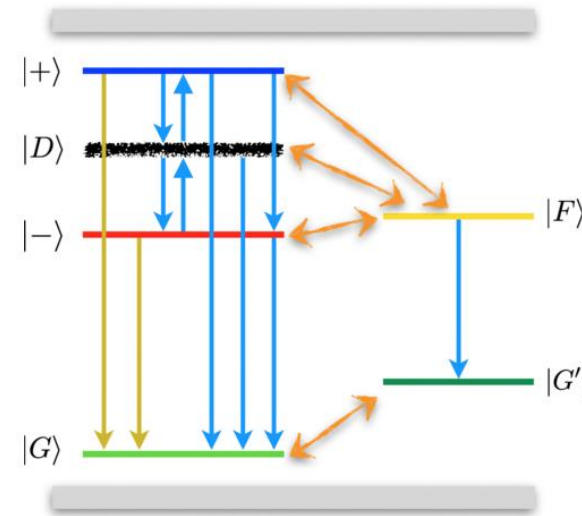
No cavity



Cavity

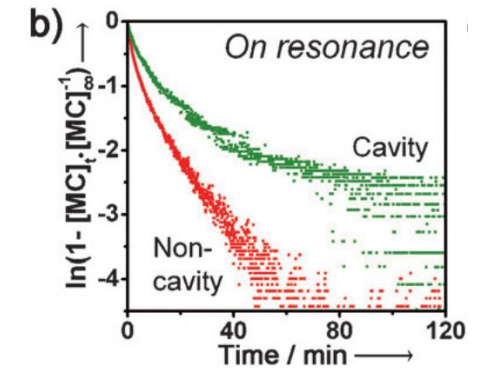
Reaction rate

J. A. Hutchison et al.,
Angewandte Chemie (2012).

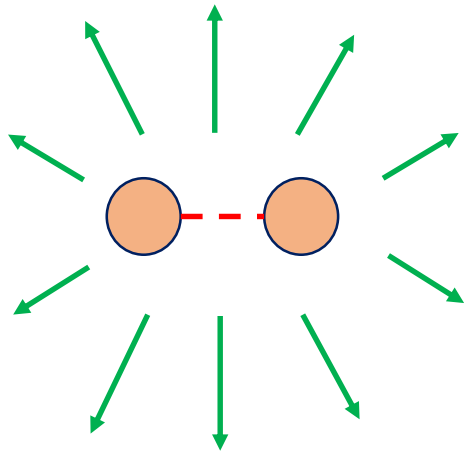


Charge-transfer chemical reactions in nanofluidic Fabry-Pérot cavities

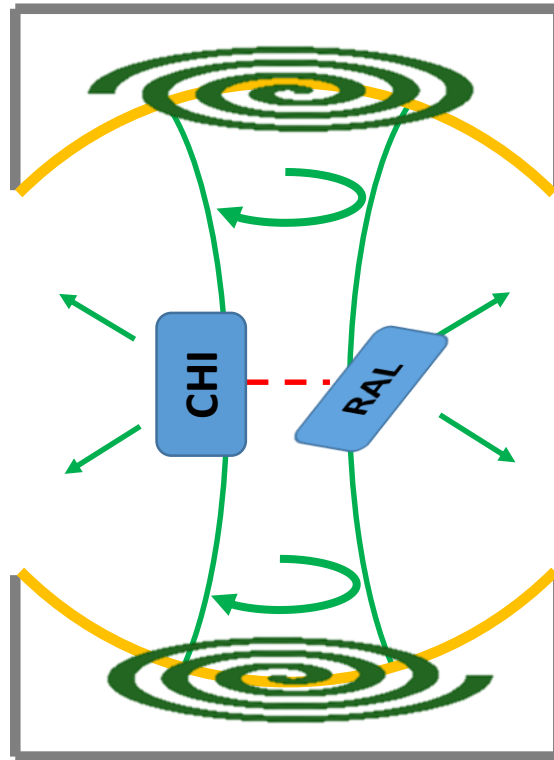
L. Mauro, K. Caicedo, G. Jonusauskas, and R. Avriller (2021)



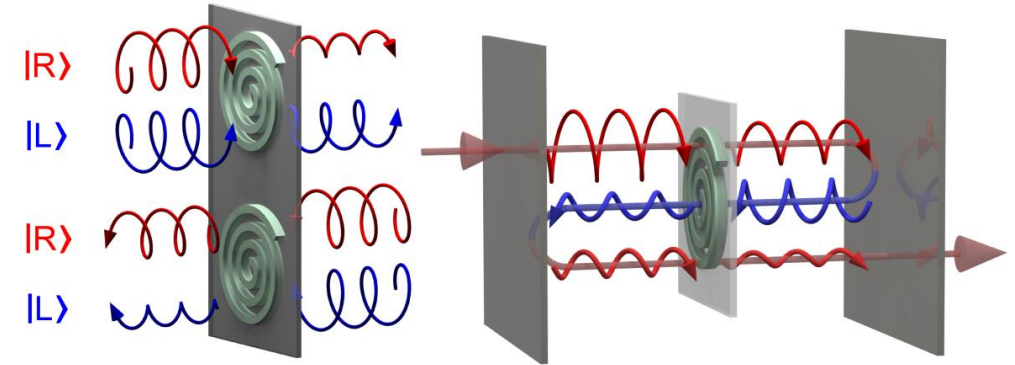
Chemical reaction
with **light** emission:



No cavity

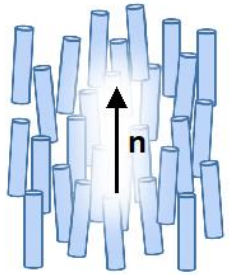


Cavity



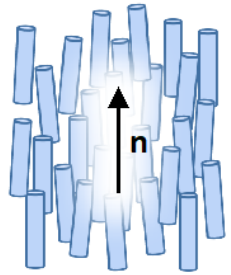
Is it possible to modify the reaction rate selectively
with the handedness of the molecule ?

NOT CHIRAL



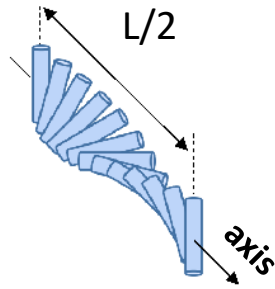
nematic

NOT CHIRAL

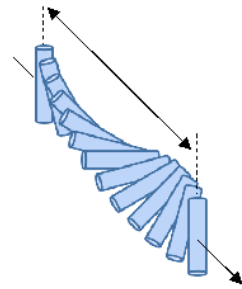


nematic

well... CHIRAL

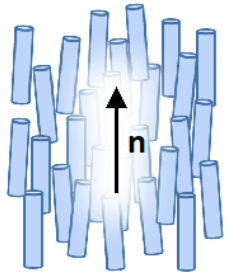


left-handed



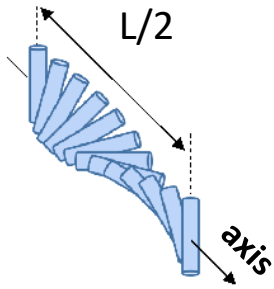
right-handed

NOT CHIRAL

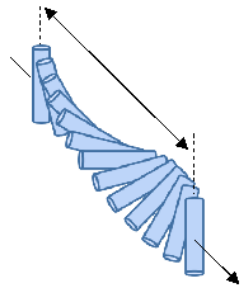


nematic

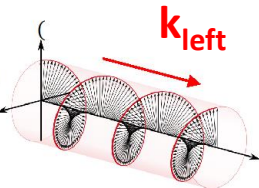
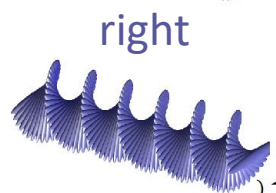
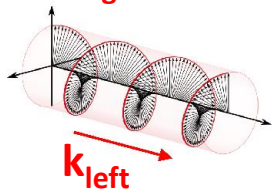
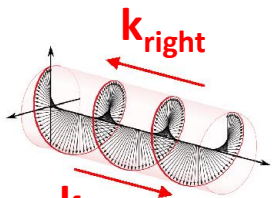
well... CHIRAL



left-handed



right-handed

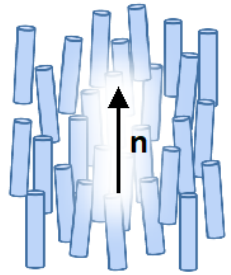


mirror

right

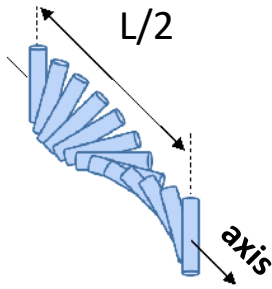
transparent

NOT CHIRAL

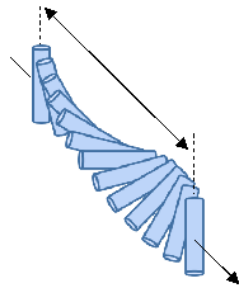


nematic

well... CHIRAL

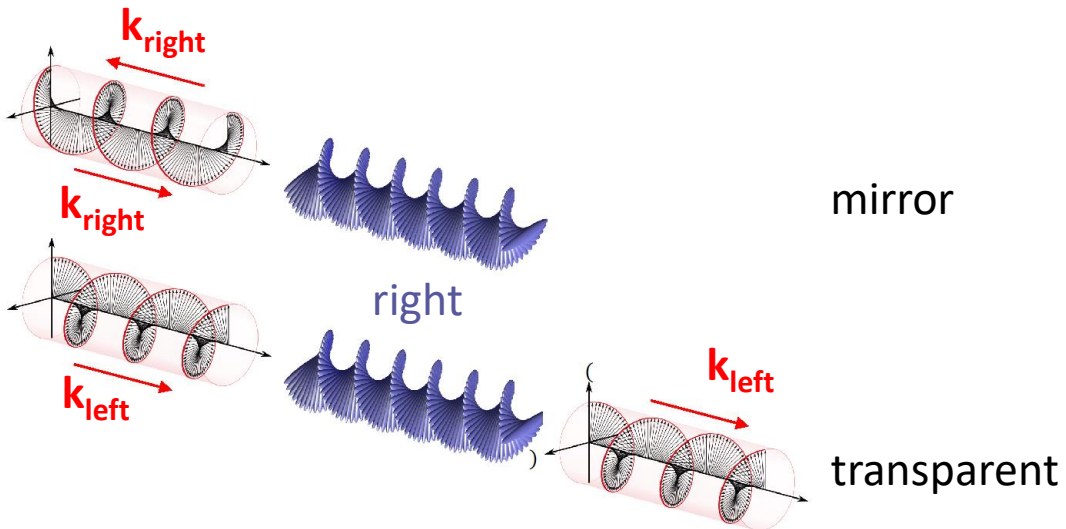


left-handed



right-handed

Light-matter
chiral recognition



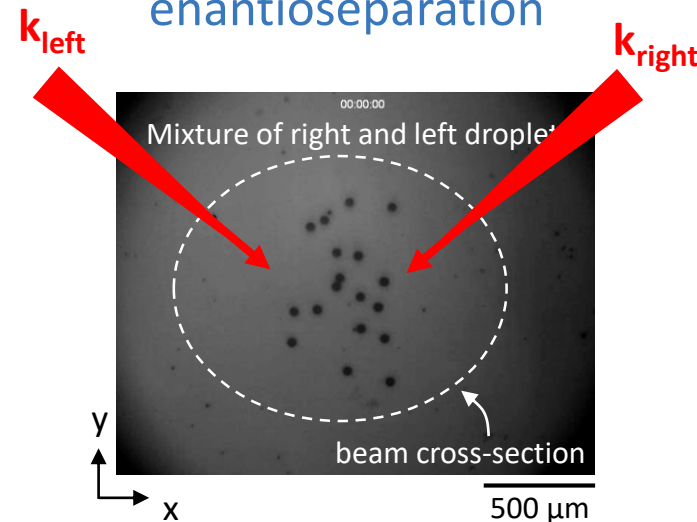
mirror

right

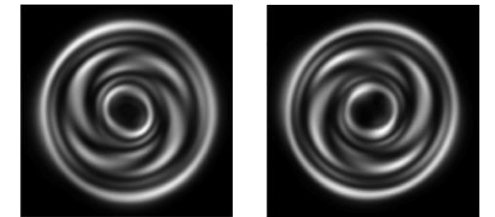
transparent

Optical
enantioseparation

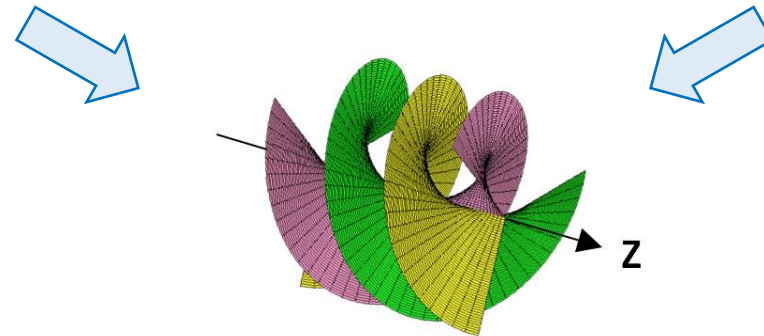
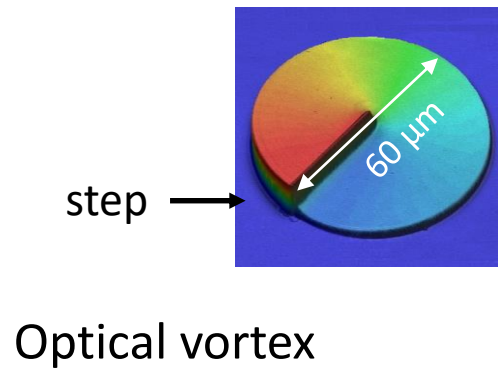
Spin-driven optical
memories



Left/right handed light



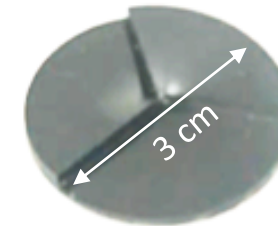
Left/right handed structures



Field equiphase
surfaces

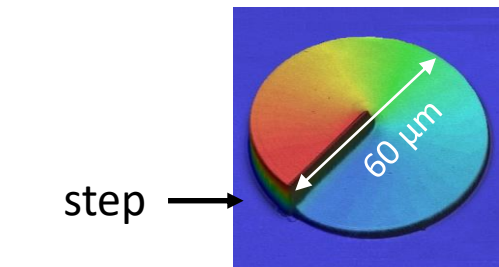


Orbital angular
momentum of waves

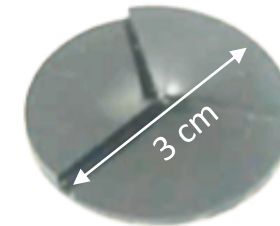
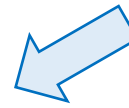
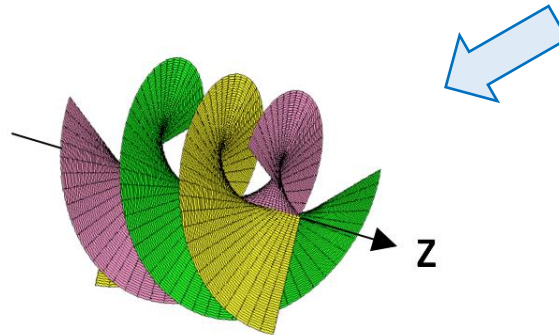
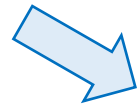


Light matter interaction: From chiral object to chiral fields

Nina Kravets
Delphine Coursault
Etienne Brasselet



Optical vortex

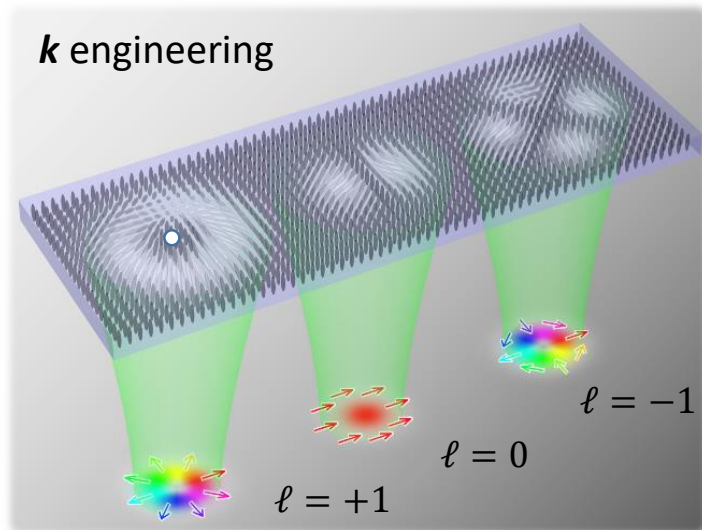


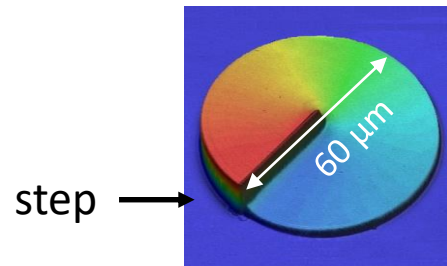
Acoustics vortex

Field equiphase
surfaces

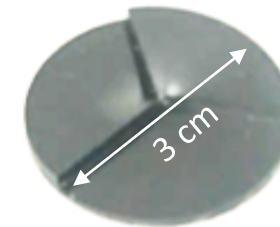
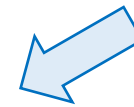
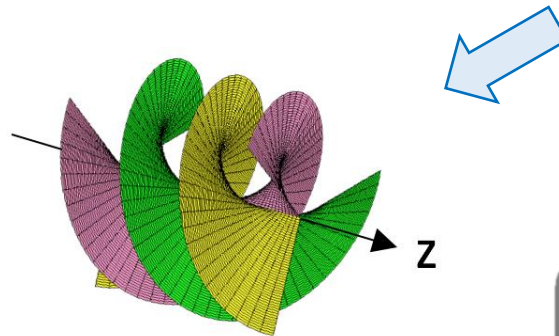
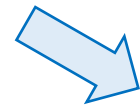


Orbital angular
momentum of waves



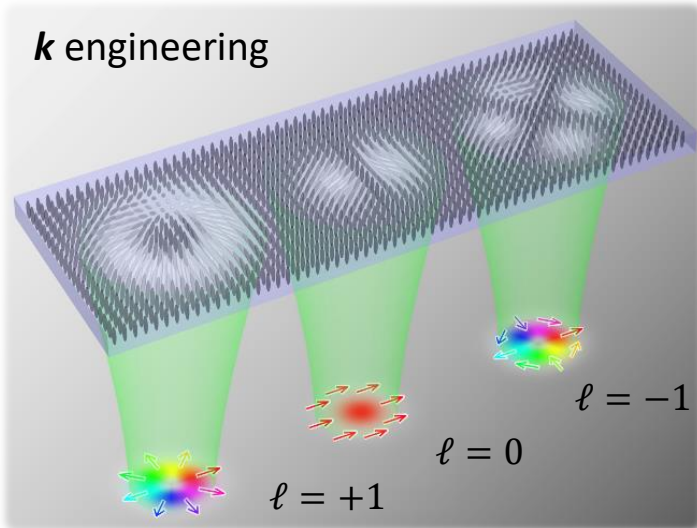


Optical vortex



Acoustics vortex

k engineering

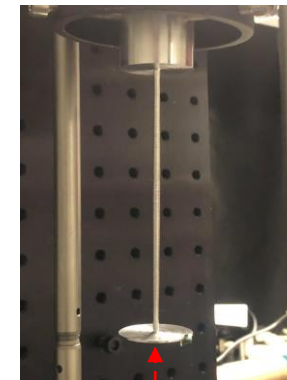


Field equiphase surfaces



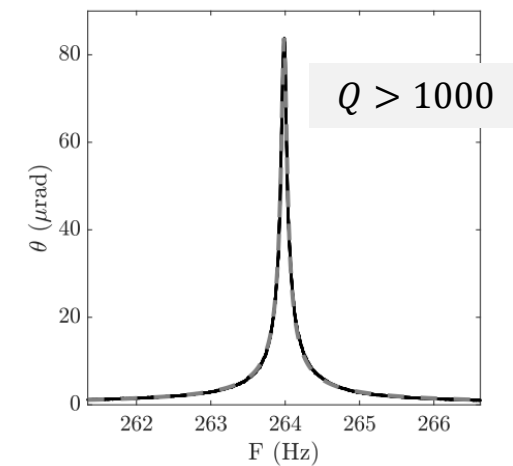
Orbital angular momentum of waves

Torsion pendulum



ultrasound

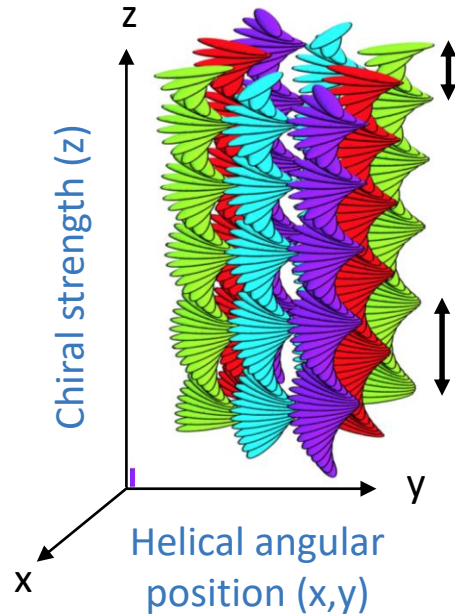
Resonant oscillator



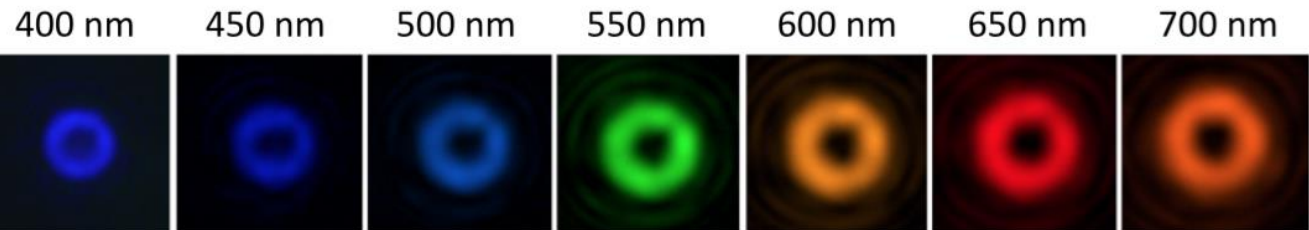
Light matter interaction: Meet the Beetles!

Nina Kravets
Delphine Coursault
Etienne Brasselet

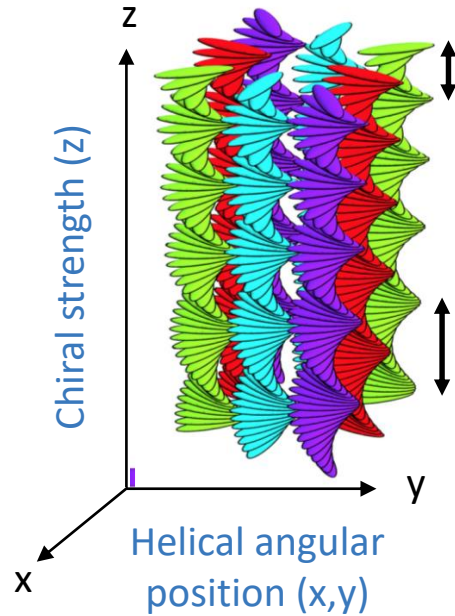
Exemple 1



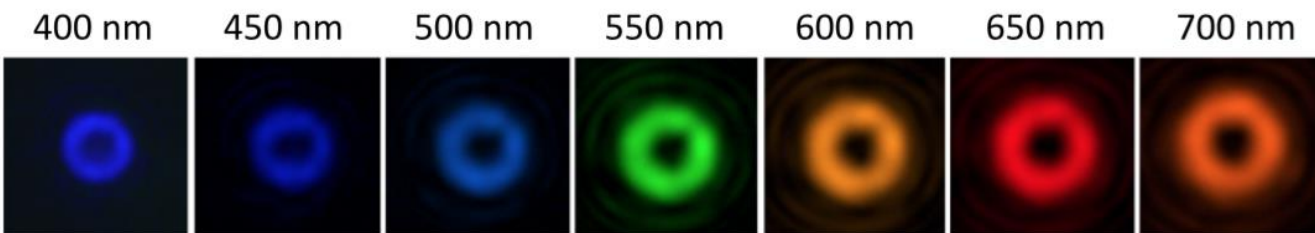
Broadband vortex generation



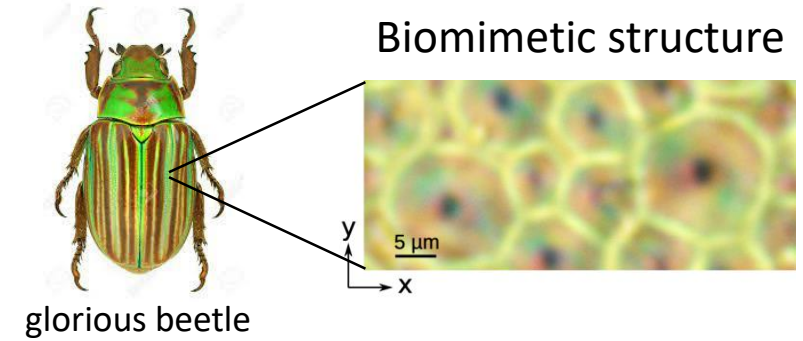
Exemple 1



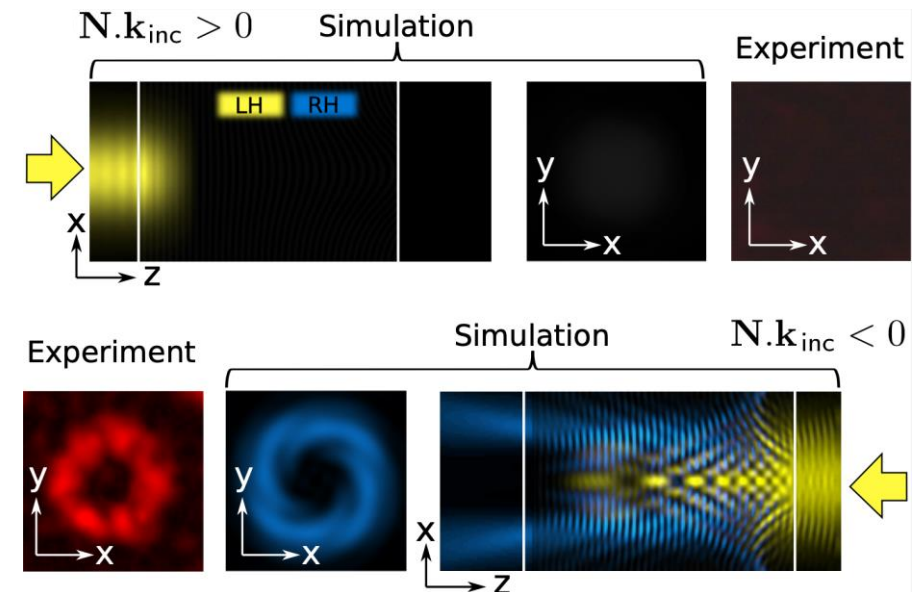
Broadband vortex generation

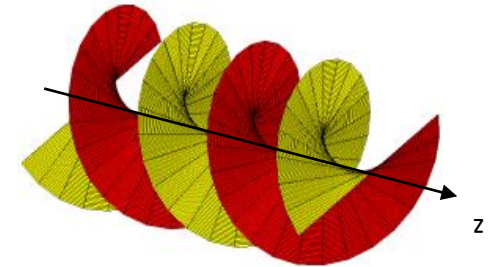
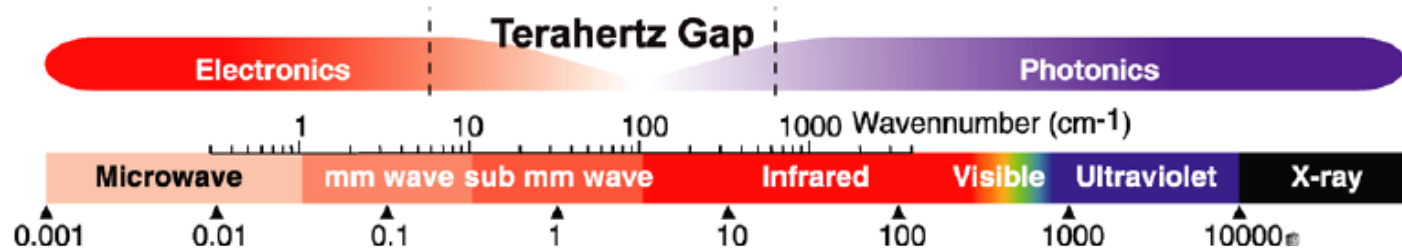


Exemple 2

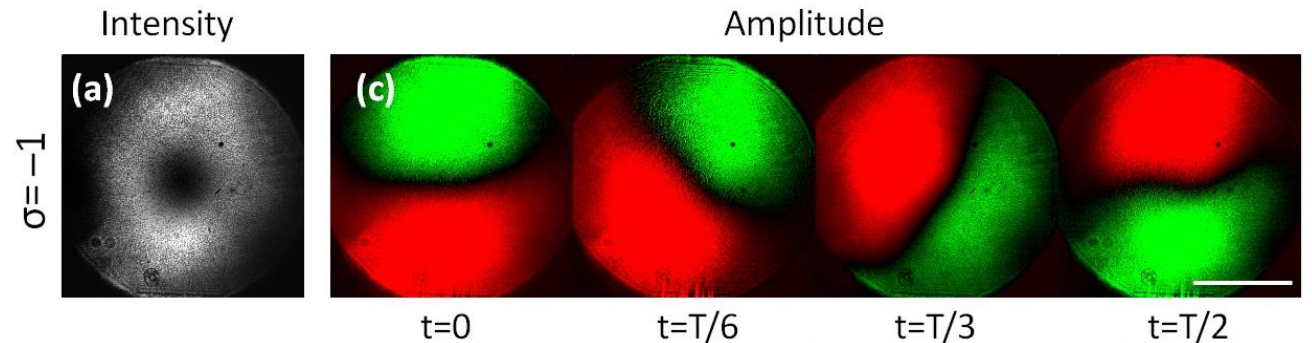
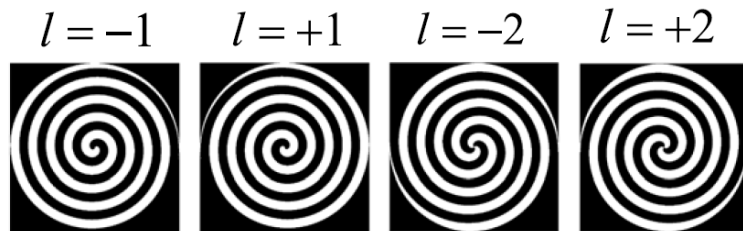
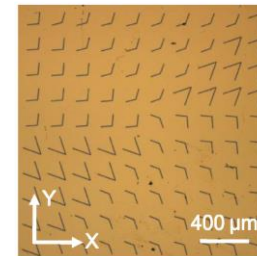
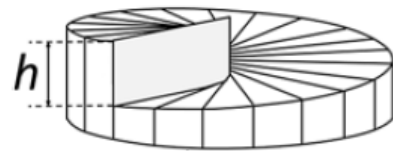


Spin-orbit photonic diode



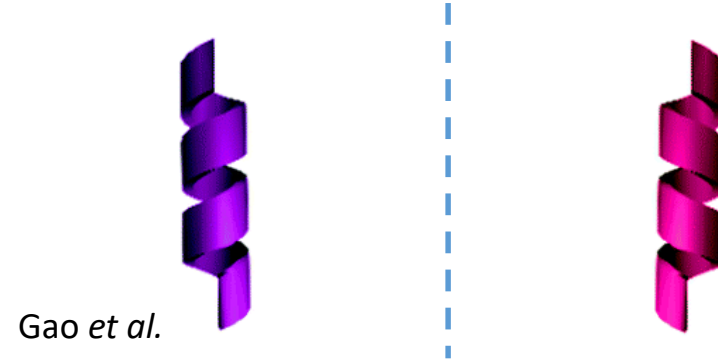


Broadband structured THz radiation with central phase singularity

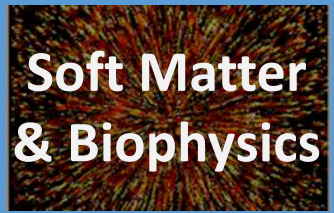


Chirality @ LOMA

I – Geometrical chirality



II – Beyond geometrical chirality



Soft Matter
& Biophysics

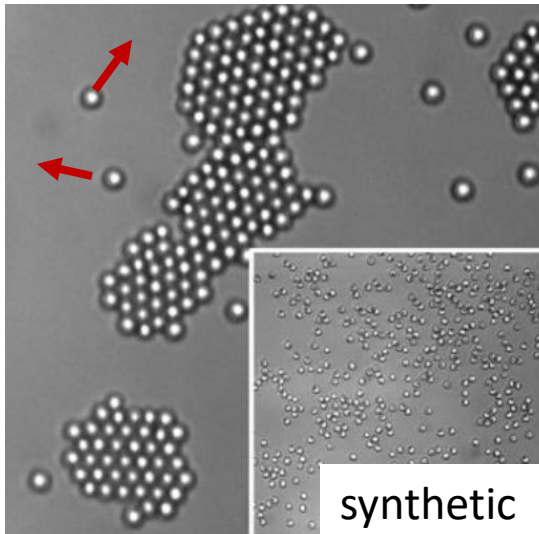
Chiral in 2D

Dynamical chirality

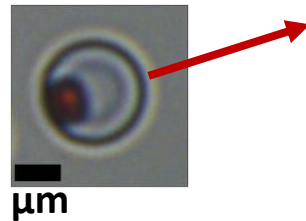
Antoine Aubret
JP Delville
Juho Lintuvuori

Thomas Barois
JF Boudet
Hamid Kellay

Active matter

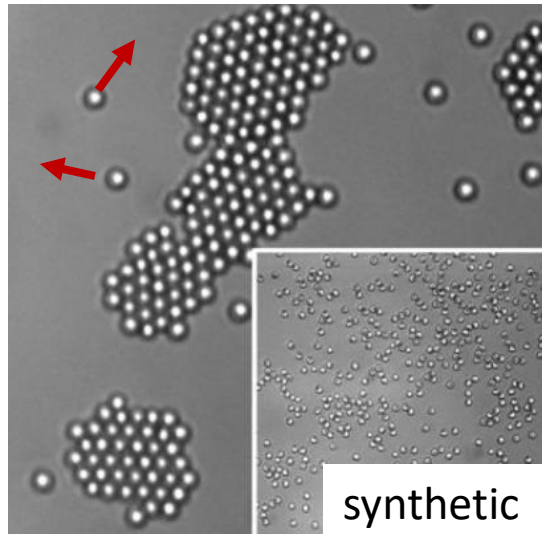


Active (heating,
chemical reaction, ...)

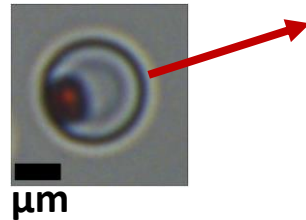


NON CHIRAL

Active matter



Active (heating,
chemical reaction, ...)



NON CHIRAL

Chiral active matter

Rotation - Spinners



Rotation + Translation – orbiting particles



Dynamical chirality

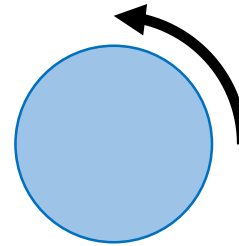
Chiral in 2D

Dynamical chirality

Antoine Aubret
JP Delville
Juho Lintuvuori

Thomas Barois
JF Boudet
Hamid Kellay

CHIRAL or NOT CHIRAL ?



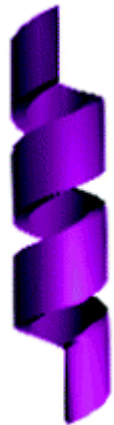
Chiral in 2D

Dynamical chirality

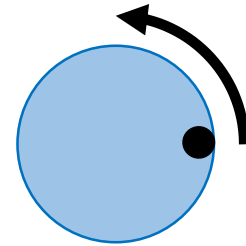
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JF Boudet
Hamid Kellay

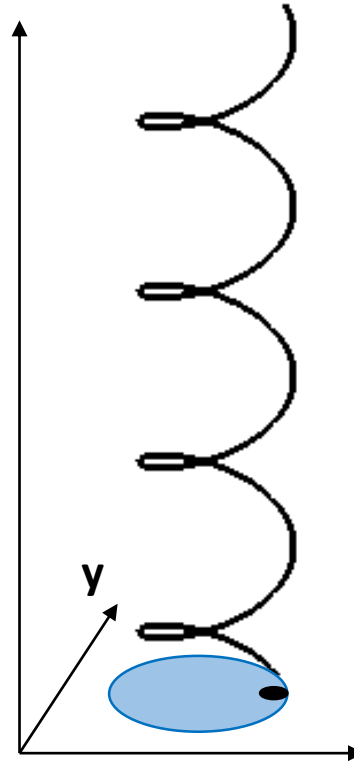
CHIRAL or NOT CHIRAL ?



Gao et al.



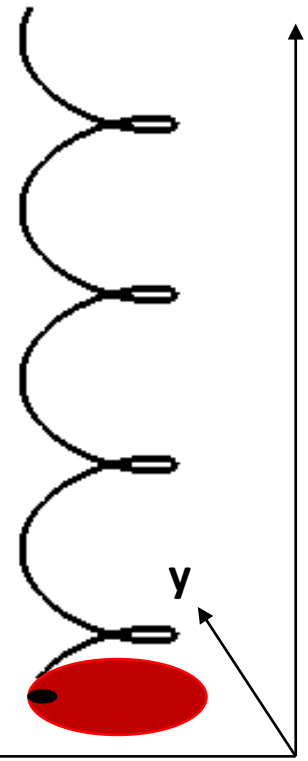
time



x

y

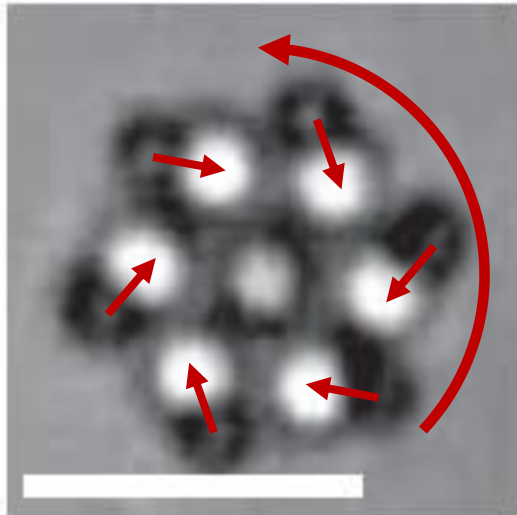
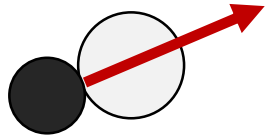
time



x'

y

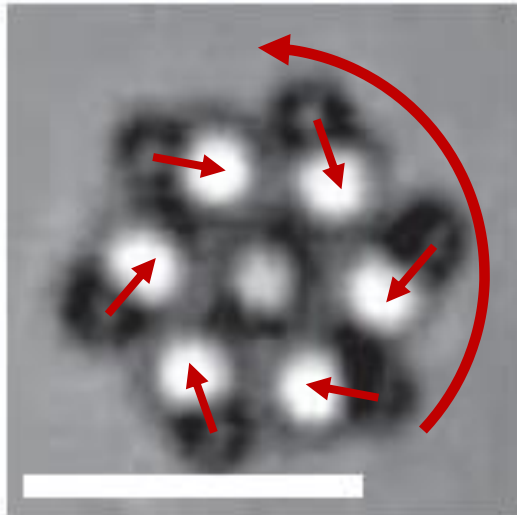
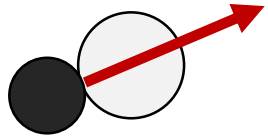
Quasi 2D



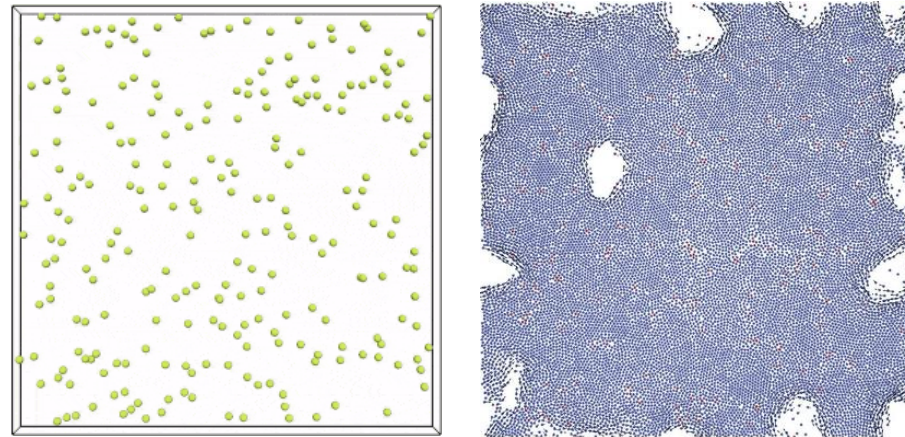
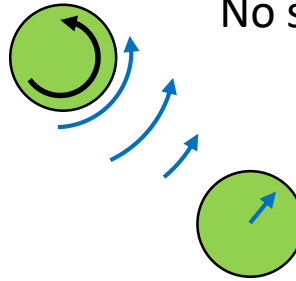
Metamachines of pluripotent colloids

A. Aubret, Q. Martinet and J. Palacci (2021)

Quasi 2D



No structural chirality



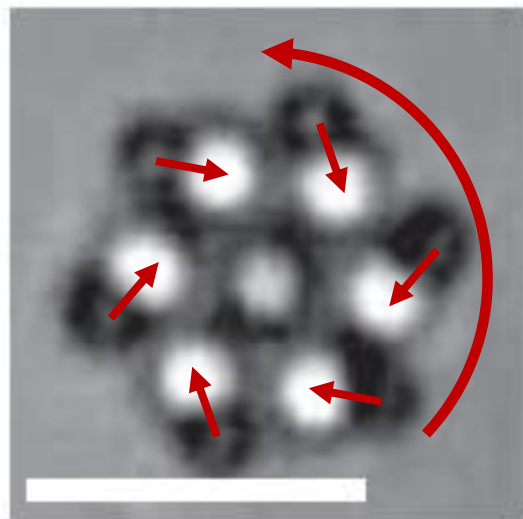
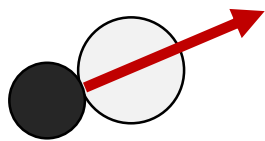
Metamachines of pluripotent colloids

A. Aubret, Q. Martinet and J. Palacci (2021)

Hydrodynamic clustering and emergent phase separation of spherical spinners

Z. Shen, J. Lintuvuori (2020)

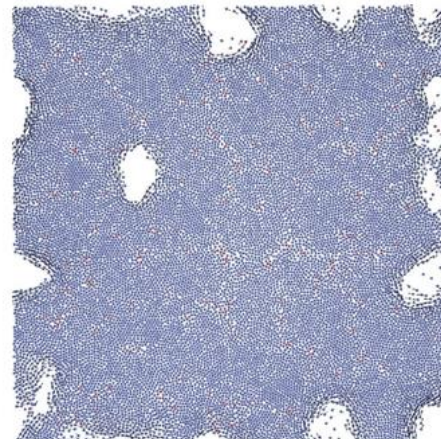
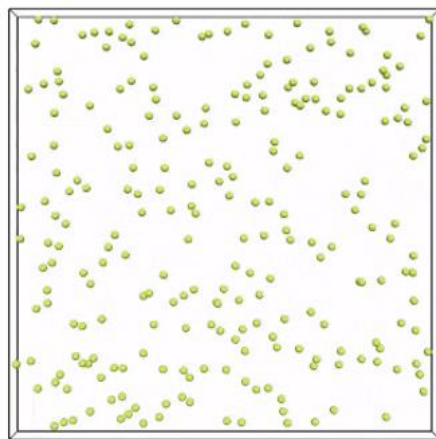
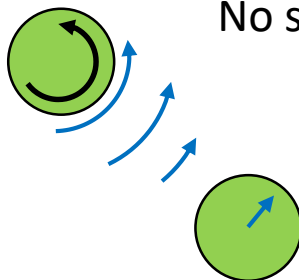
Quasi 2D



Metamachines of pluripotent colloids

A. Aubret, Q. Martinet and J. Palacci (2021)

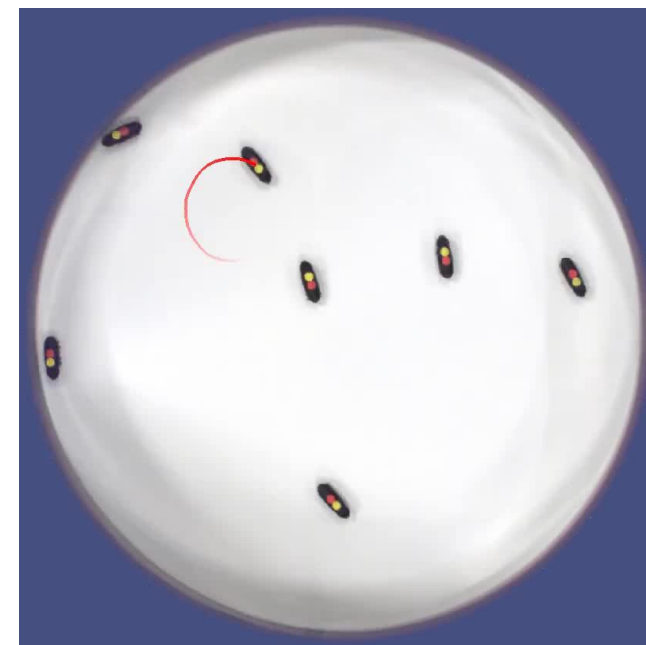
No structural chirality



Hydrodynamic clustering and emergent phase separation of spherical spinners

Z. Shen, J. Lintuvuori (2020)

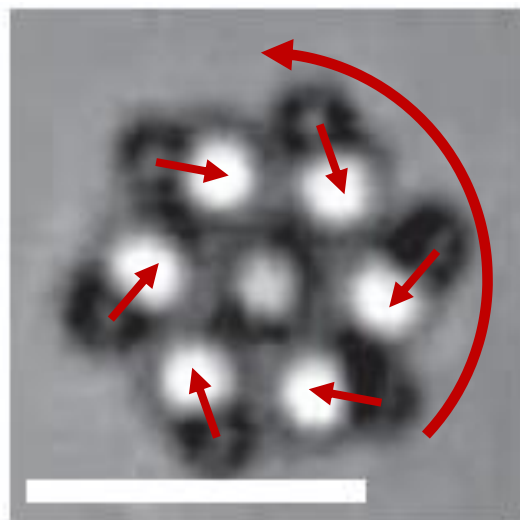
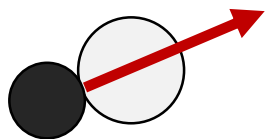
Meet the beetles! (again)



Sorting and Extraction of Self-Propelled Chiral Particles by Polarized Wall Currents

T. Barois, JF. Boudet, J. Lintuvuori, and H. Kellay (2020)

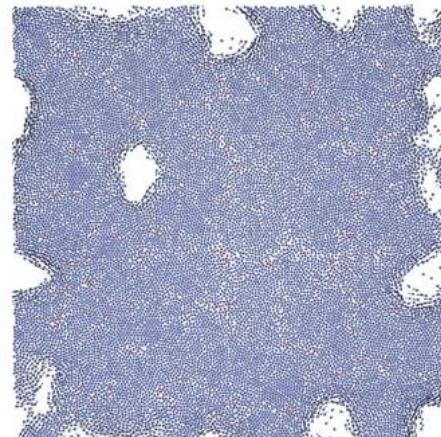
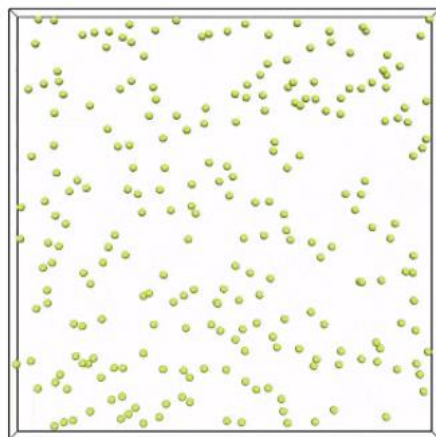
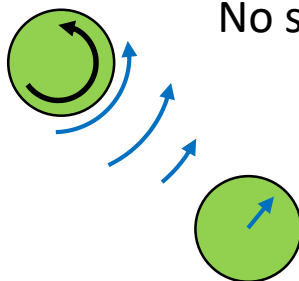
Quasi 2D



Metamachines of pluripotent colloids

A. Aubret, Q. Martinet and J. Palacci (2021)

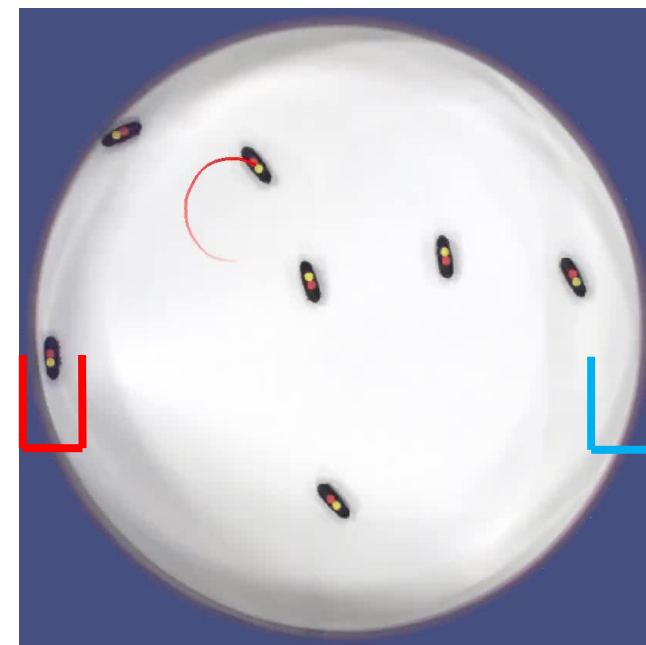
No structural chirality



Hydrodynamic clustering and emergent phase separation of spherical spinners

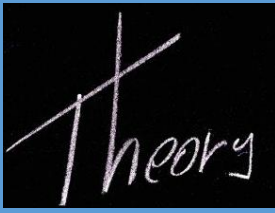
Z. Shen, J. Lintuvuori (2020)

Meet the beetles! (again)



Sorting and Extraction of Self-Propelled Chiral Particles by Polarized Wall Currents

T. Barois, JF. Boudet, J. Lintuvuori, and H. Kellay (2020)

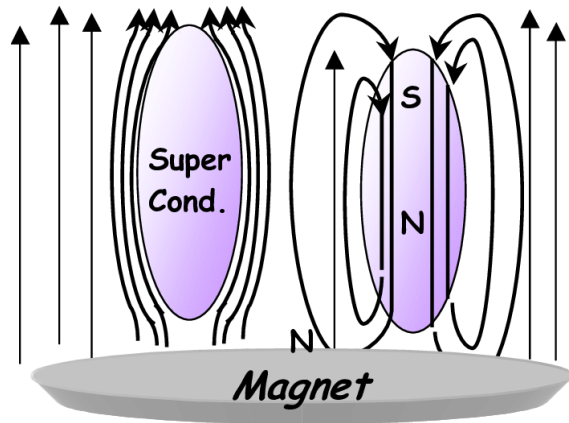


Chiral in 2D Magnetism and superconductivity

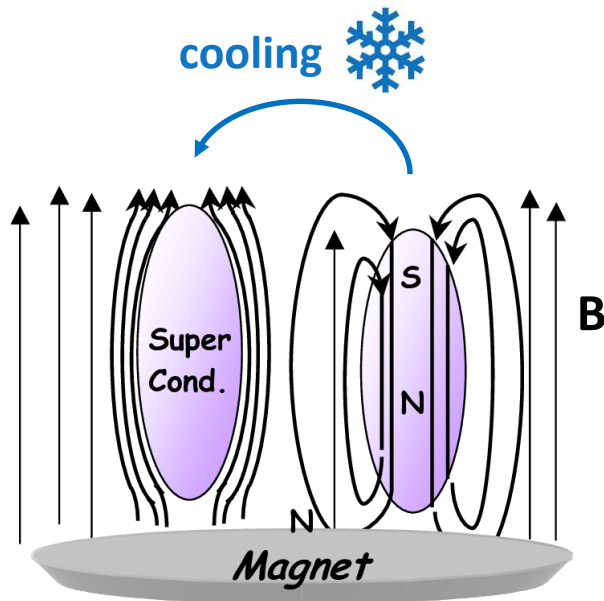
Alexander Buzdin

Superconducting phase

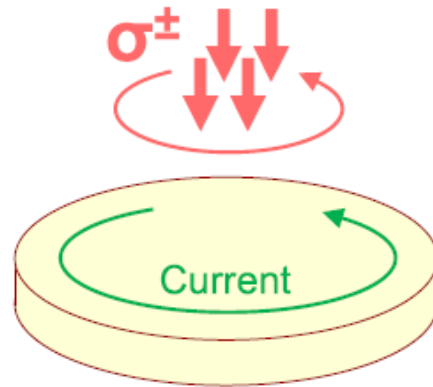
cooling ❄️



Superconducting phase

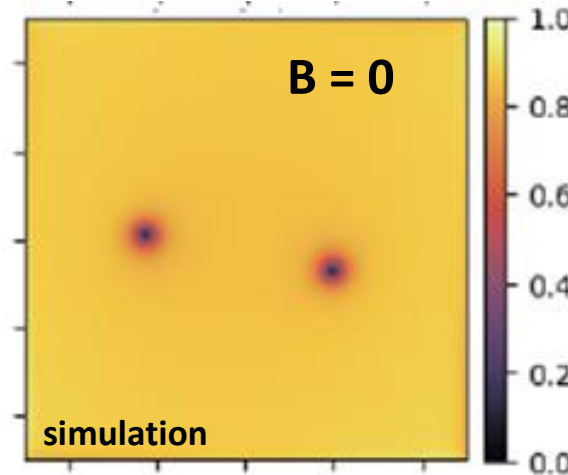


Chiral light
(circularly polarized)

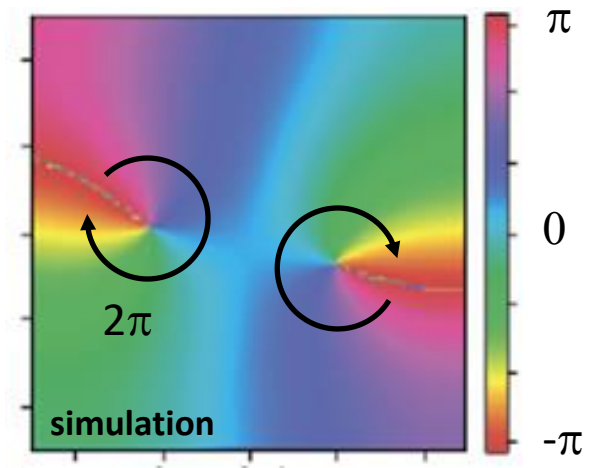


Superconducting disk

Superconducting state



Quantum phase

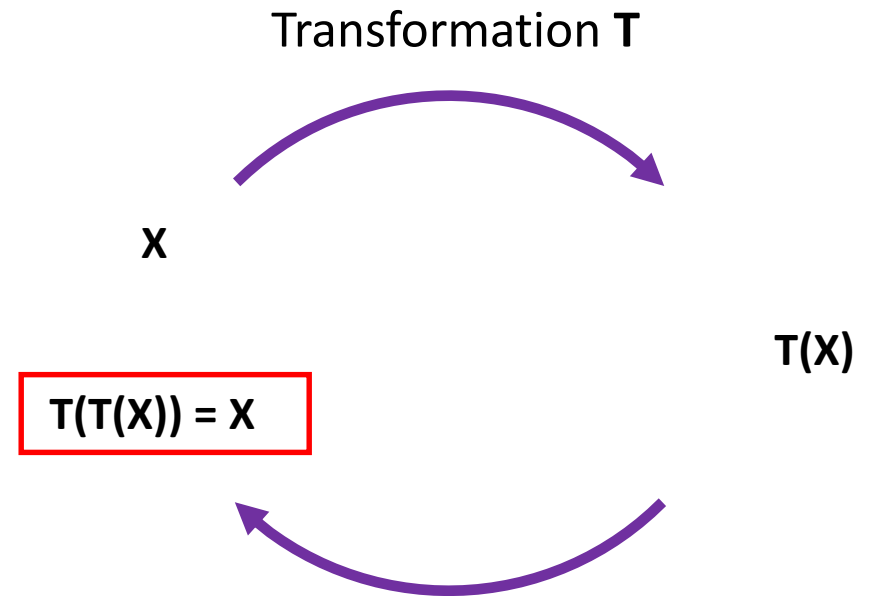
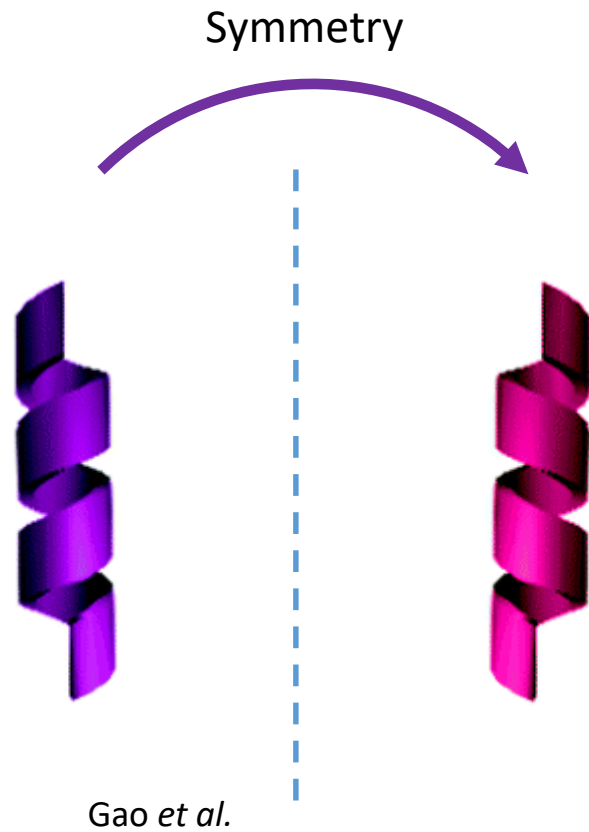


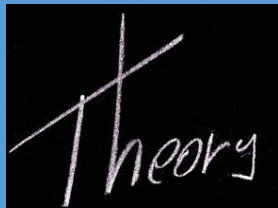
Topological filaments

Inverse Faraday Effect for Superconducting Condensates

S. V. Mironov, A. S. Mel'nikov, I. D. Tokman, V. Vadimov, B. Lounis, and A. I. Buzdin, Phys. Rev. Lett. 2021

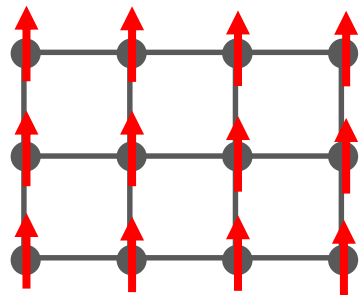
Chirality @ LOMA



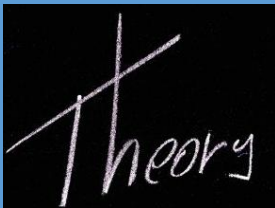


Chirality in magnetism

Ludovic Jaubert
Sébastien Burdin

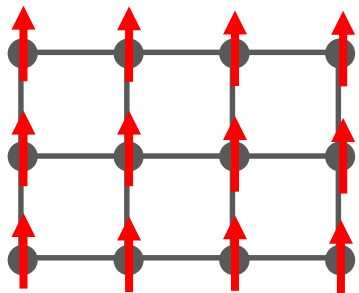


NOT CHIRAL

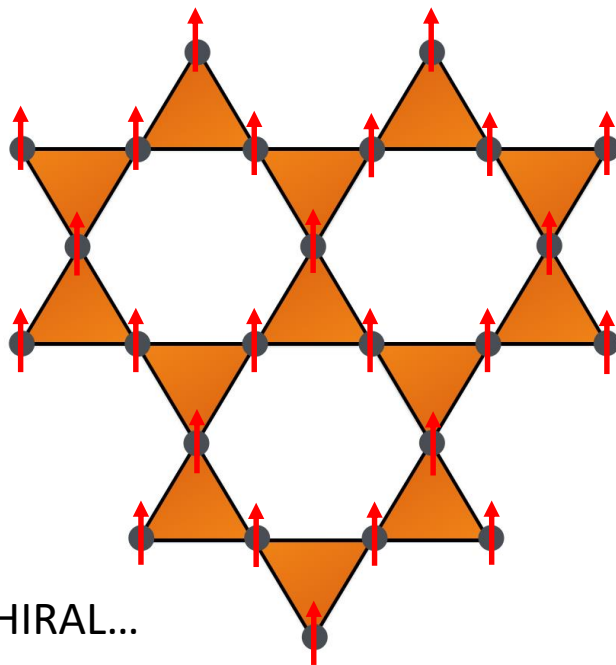


Chirality in magnetism

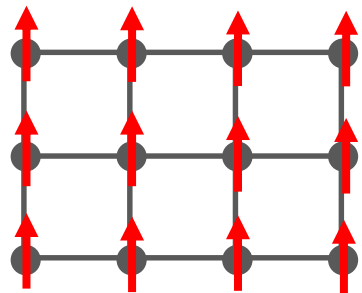
Ludovic Jaubert
Sébastien Burdin



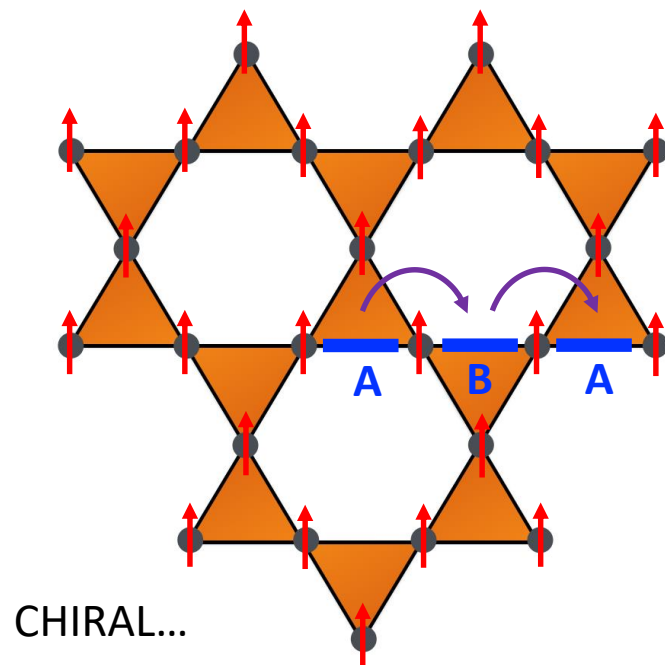
NOT CHIRAL



CHIRAL...

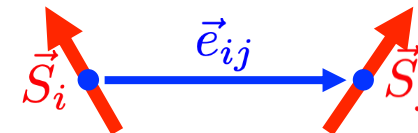


NOT CHIRAL

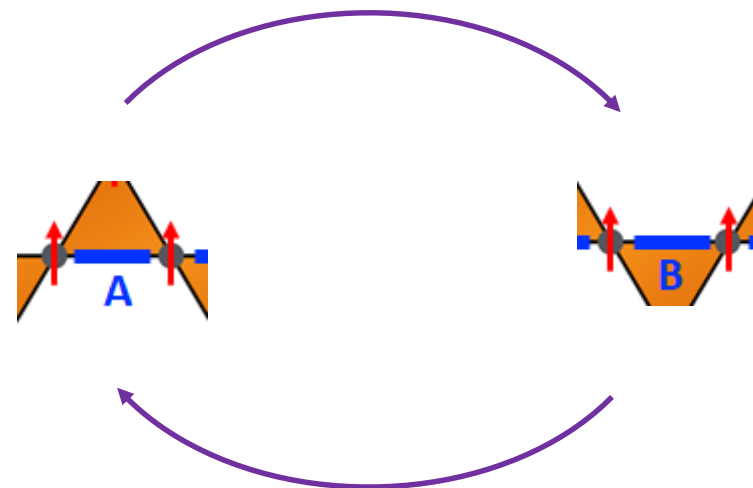


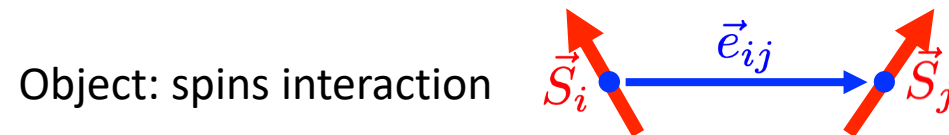
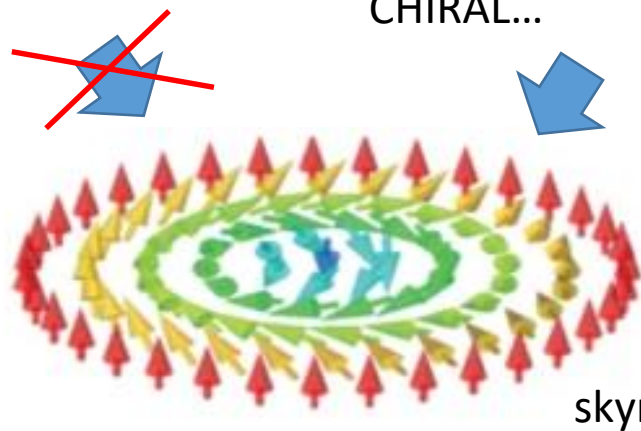
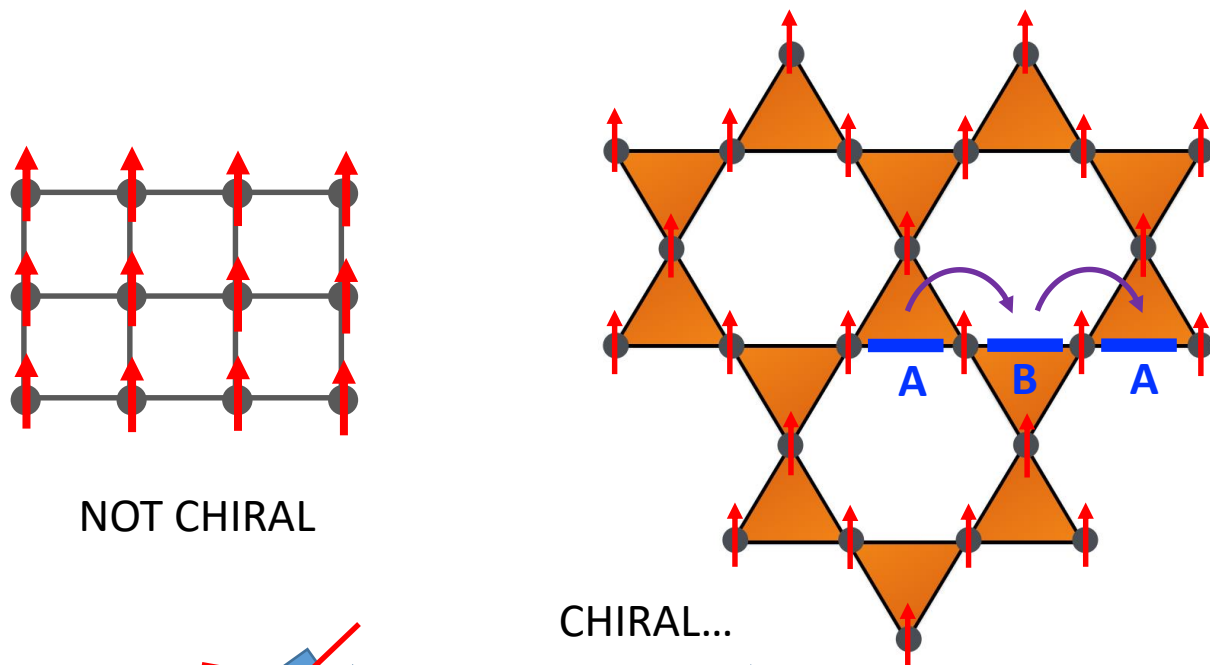
CHIRAL...

Object: spins interaction

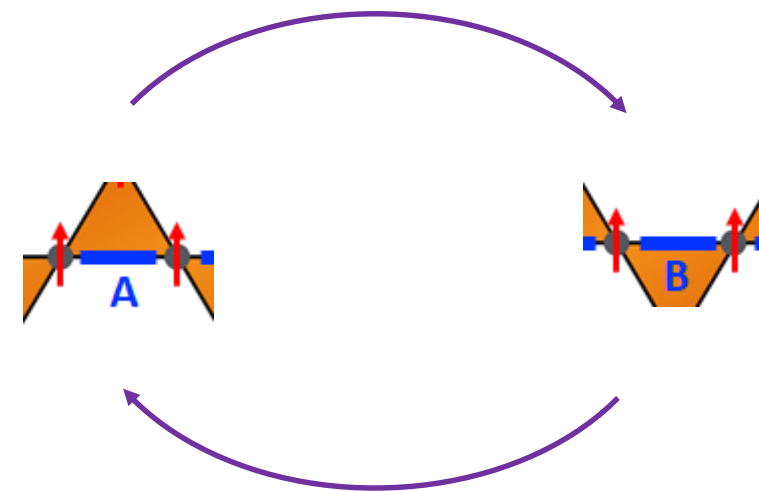


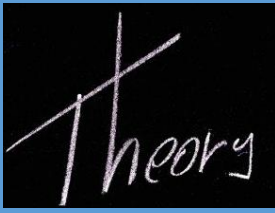
Transformation: translation





Transformation: translation

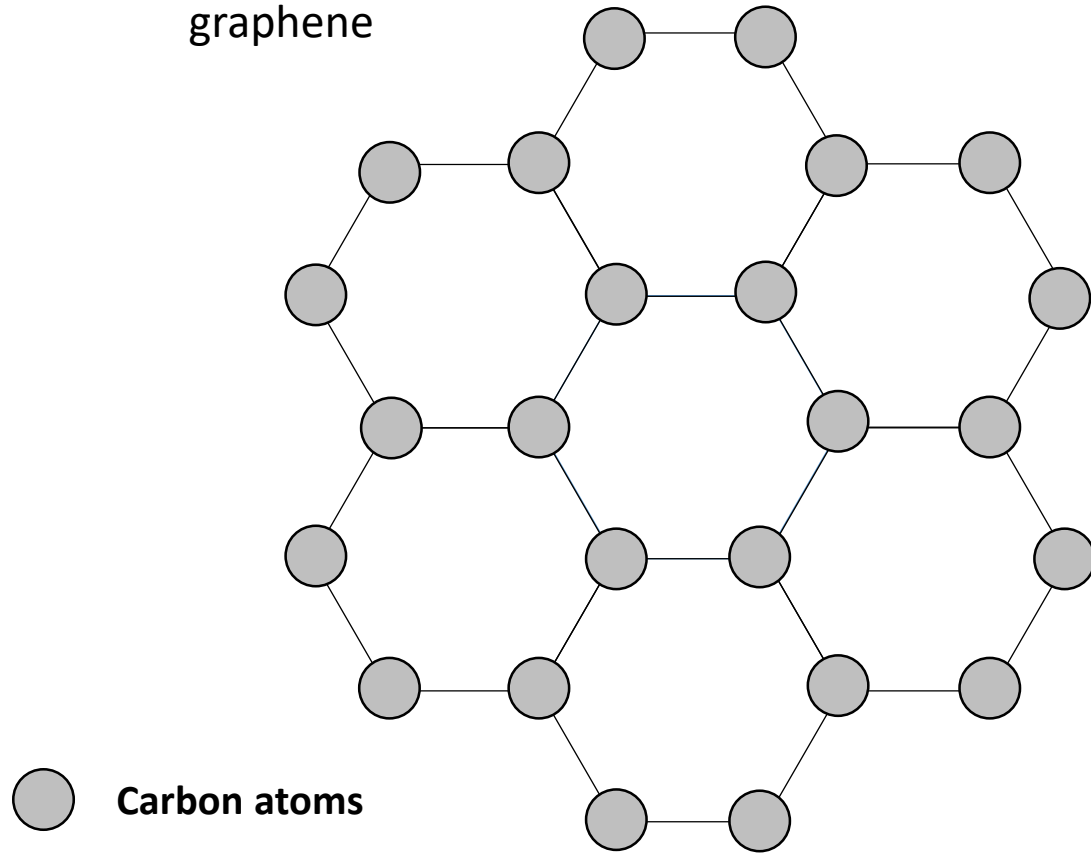


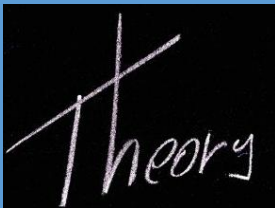


Chirality and quantum phases

Clément Dutreix
Jérôme Cayssol

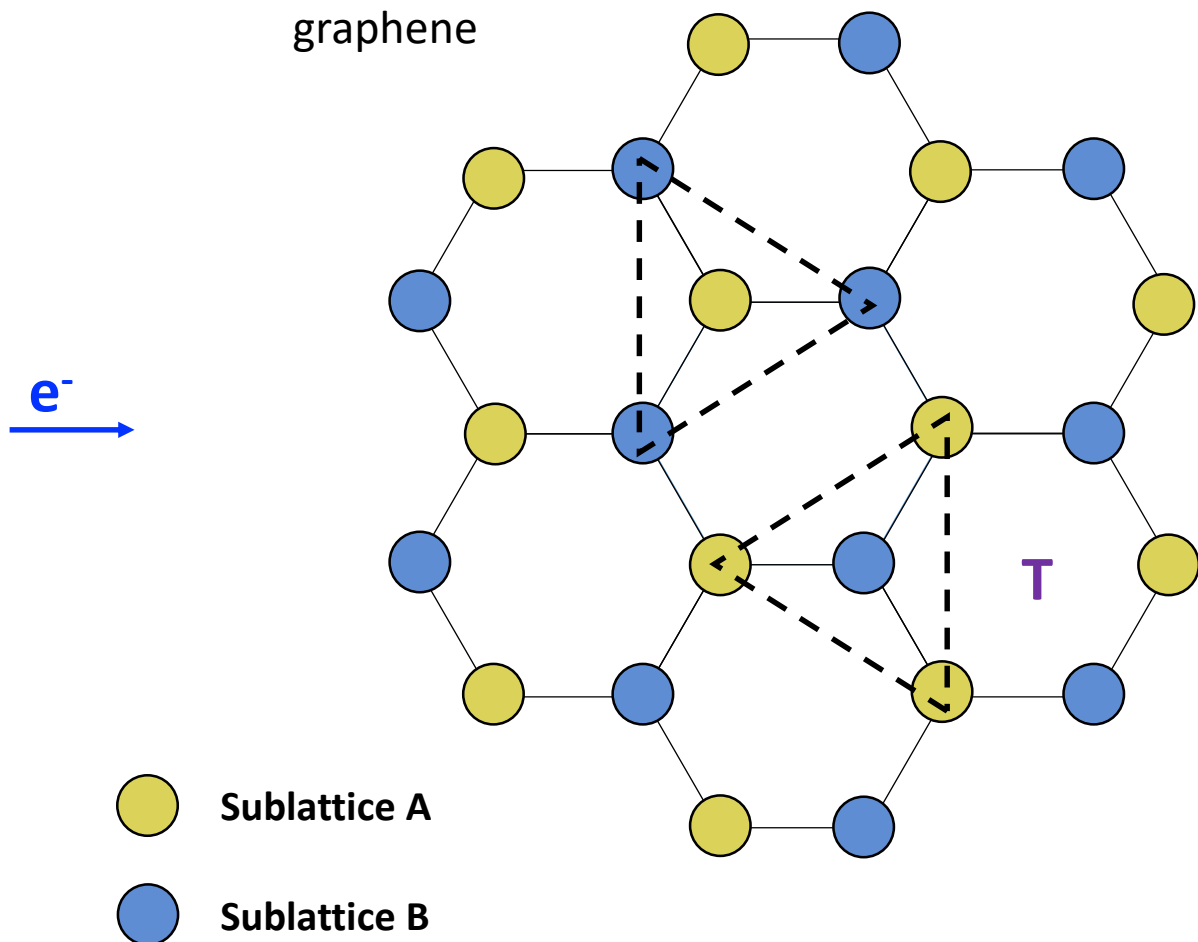
graphene

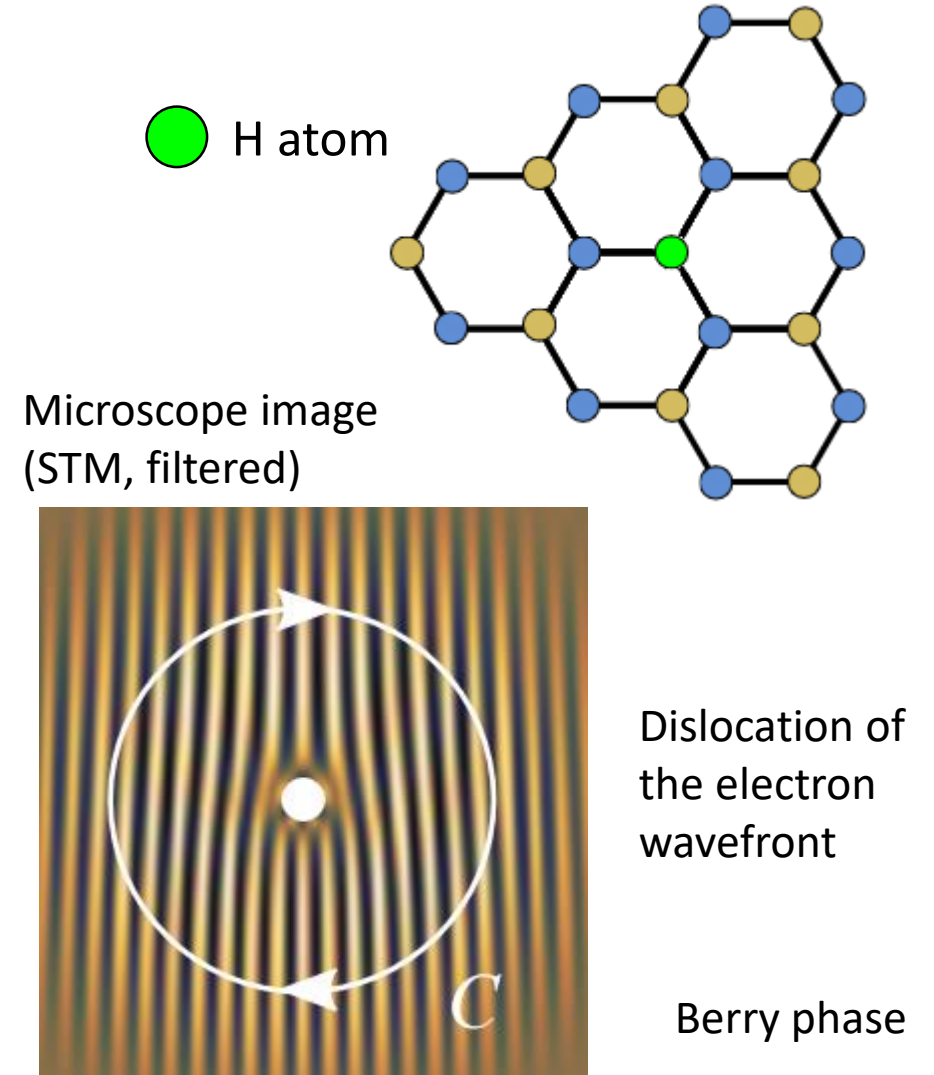
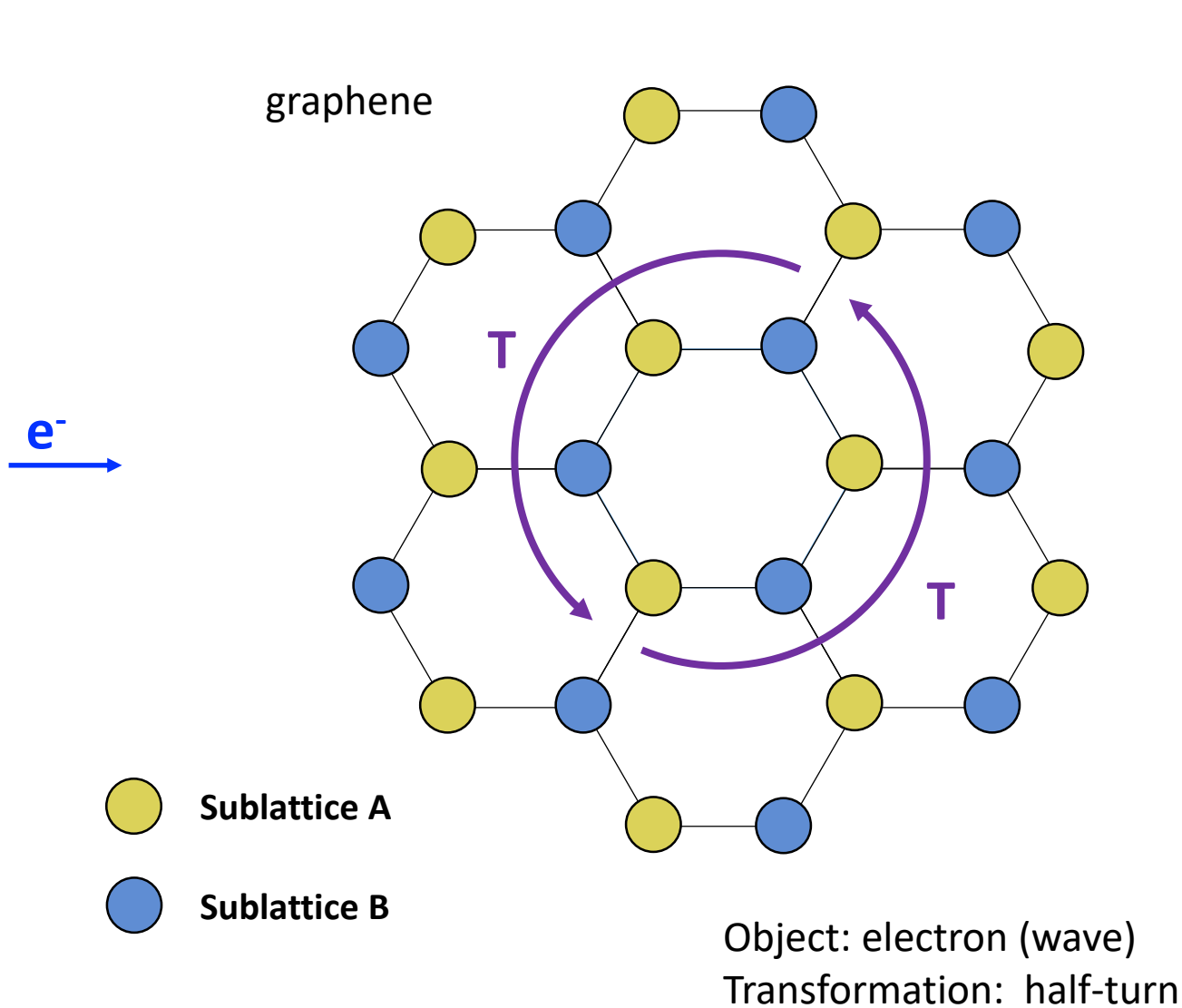




Chirality and quantum phases

Clément Dutreix
Jérôme Cayssol





Chirality @ LOMA

