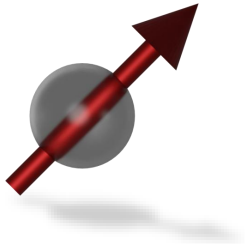
EMERGENT TOPOLOGY AND UNCONVENTIONAL ORDER IN QUANTUM MATTER

Spanish–German WE-Heraeus-Seminar

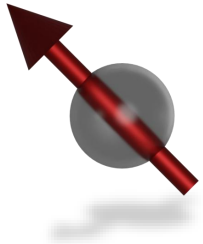
Seminar, September 8–10, 2026 | Palacio de Congresos Conde Ansúrez, Valladolid, Spain

SPIN PHENOMENA INTERDISCIPLINARY CENTER SPICE

WILHELM UND ELSE HERAEUS-STIFTUNG



Spin defects for spin-wave imaging



Valladolid, 09/09/2026

Samuel Mañas-Valero samuel.manas@uv.es

Newton 1, 1, 100018, 2925
Nature Communications 17, 379, 2026

With Y. Doedes, A. Bondarenko, M. Borst, S. Kurdi, T. Poirier, J. Edgar, V. Jacques, Y. Blanter, T. van der Sar

TU Delft

VNIVERSITAT DE VALÈNCIA



Magnons at the Pisuerga

Valladolid, 09/09/2026

Samuel Mañas-Valero samuel.manas@uv.es

Newton 1, 1, 100018, 2925
Nature Communications 17, 379, 2026

With Y. Doedes, A. Bondarenko, M. Borst, S. Kurdi, T. Poirier, J. Edgar, V. Jacques, Y. Blanter, T. van der Sar

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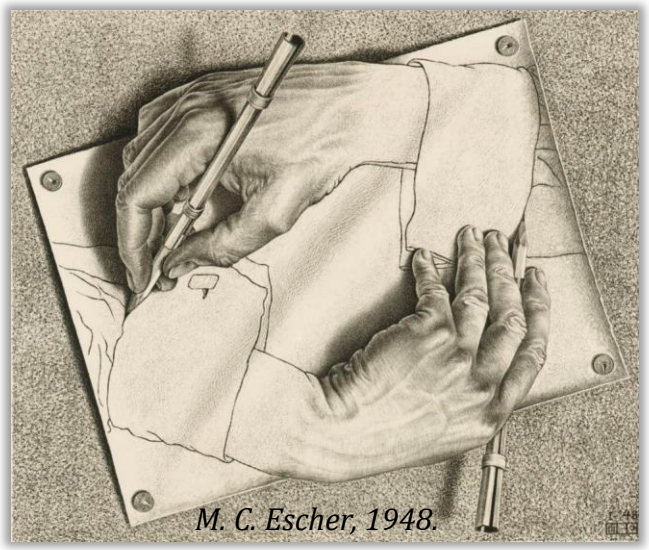
Aprovechando que el Pisuerga pasa por Valladolid…

Taking advantage of the fact that the Pisuerga runs through Valladolid…

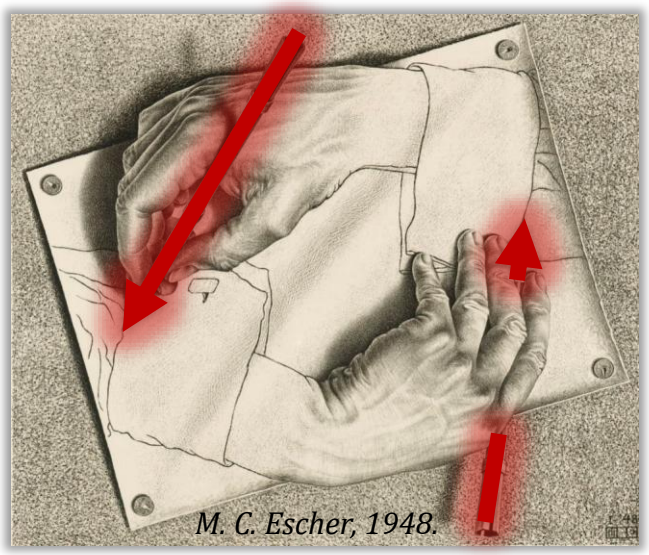
A Spanish idiom used to introduce a totally unrelated topic, poking fun at the abruptness of the transition by citing an obvious, trivial fact as a fake segue.

Roughly equivalent to "apropos of nothing" or "on a completely unrelated note."

About my research: Spins and Materials



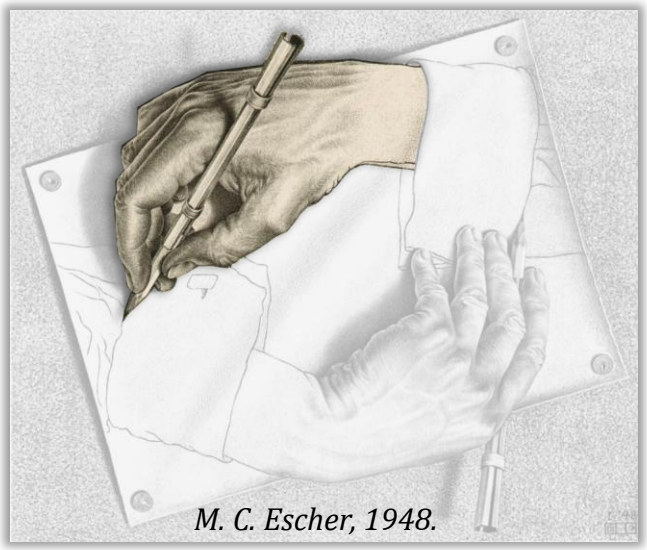
About my research: Spins and Materials



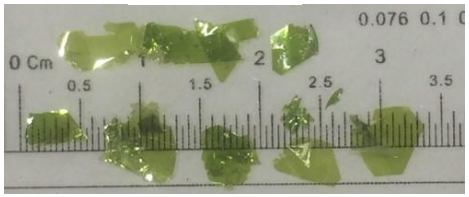
Interplay between crystal growth and low-dimensional magnetism

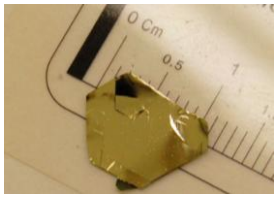
From Crystal Growth

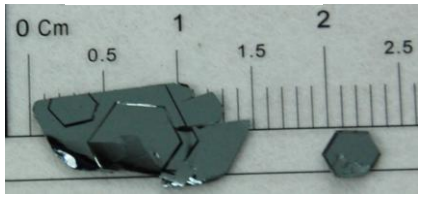
Solid state chemsitry (inorganic compounds)
Coordination chemistry (molecular magnetism)
Thin-film growth (spintronics)



$MnPS_3$ TiS_2 $2H\text{-}NbSe_2$ HfS_2









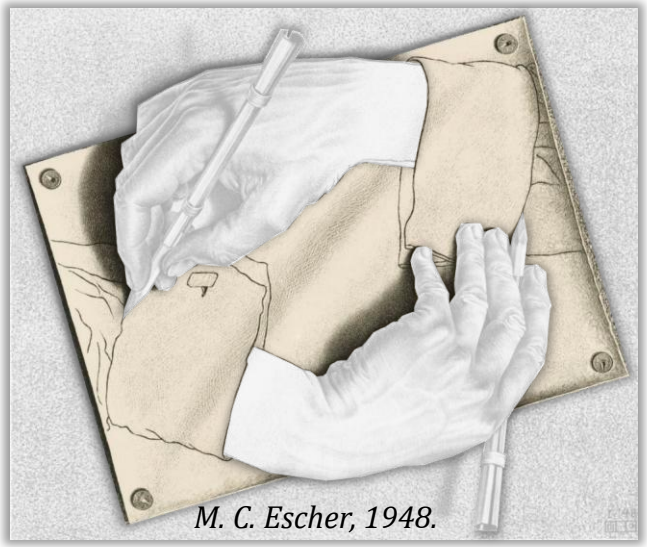
About my research: Spins and Materials

Interplay between crystal growth and low-dimensional magnetism

From Crystal Growth

To Physical Characterization

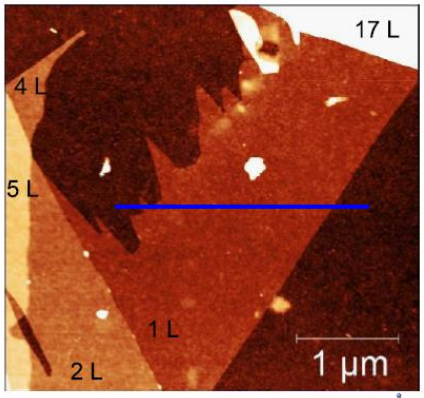
- 2D materials (Valencia, prof. E. Coronado)
- Spin waves in thin-films (Delft, prof. T. van der Sar)



M. C. Escher, 1948.

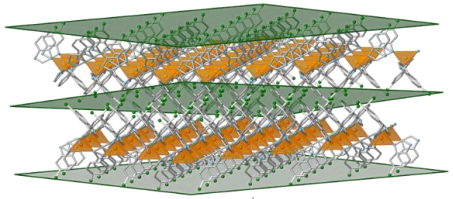
About my research: Spins and Materials

2D molecular magnets



Metal changes
Tune Magnetic properties

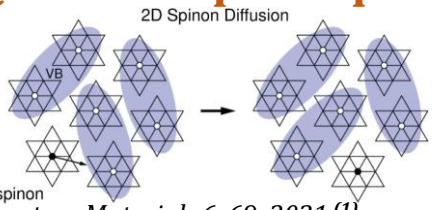
MUV-1-Cl (Fe)



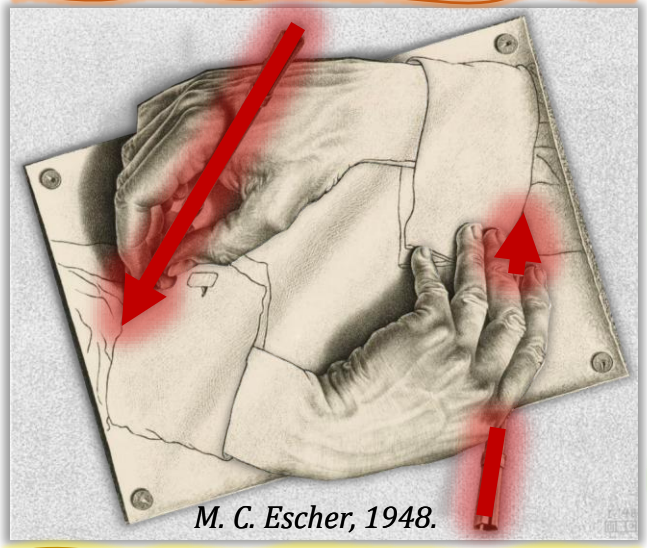
Structure modification
Ligand changes

Nature Chemistry 10, 1001, 2018 (1)
JACS 143, 18502, 2021 (1)
Advanced Materials 2026.
DOI: 10.1002/adma.202517382 (*)

Quantum Spin Liquids

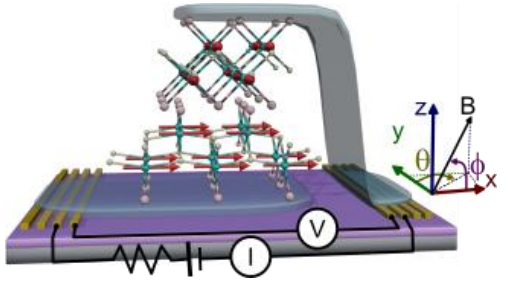


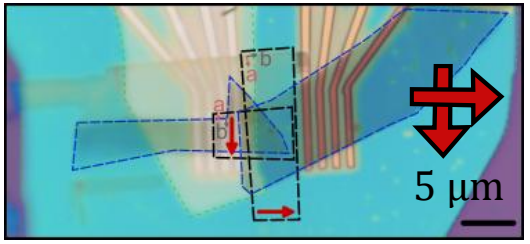
npj Quantum Materials 6, 69, 2021 (1)
Advanced Electronic Materials 7, 2000987, 2021 (*)
ACS Nano 15, 7, 11898, 2021 (*)

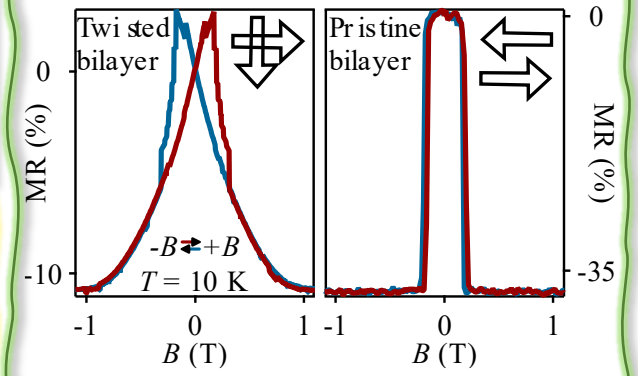


M. C. Escher, 1948.

Probing and twisting 2D inorganic vdW magnets:

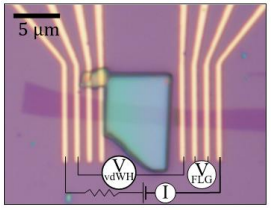


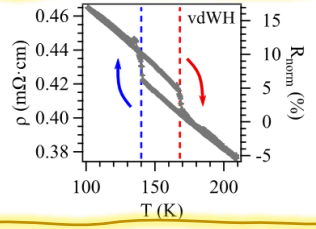


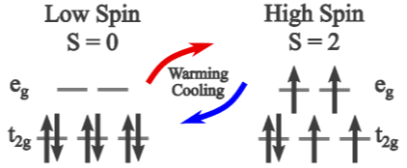


Advanced Materials 34, 2204940, 2022 (*)
Advanced Materials 35, 2307195, 2023 (*)
Nature Materials 23, 212, 2024 (*)
Advanced Materials 37, 2415774, 2025 (*)

Stimuli-responsive van der Waals heterostructures







(1) First author. (*) Corresponding author.

For Today

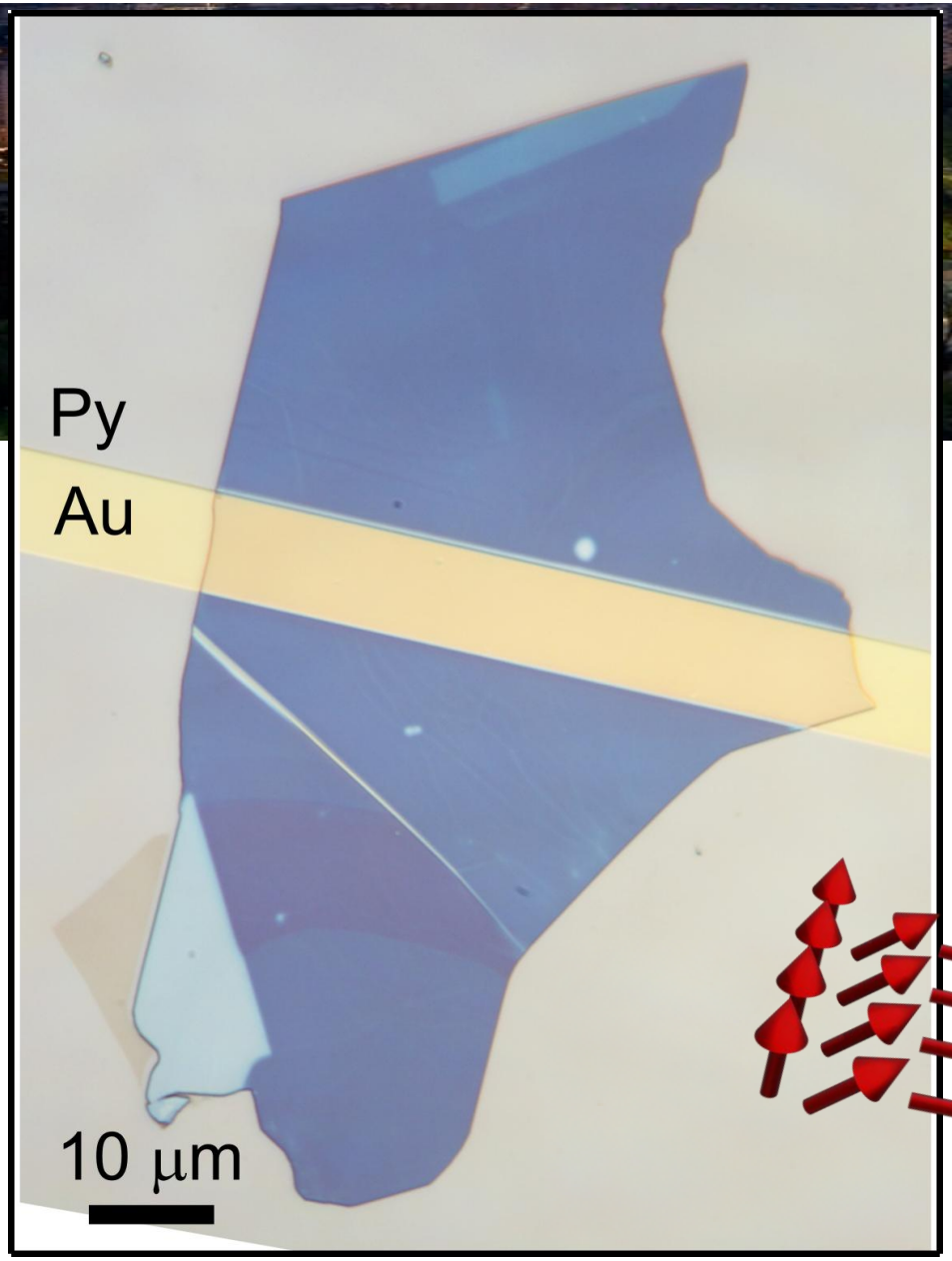


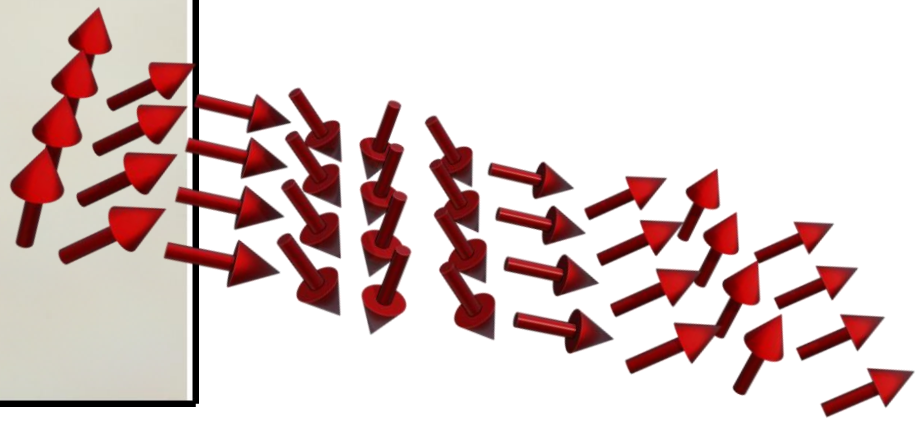
Aprovechando que el Pisuerga pasa por Valladolid…

Taking advantage of the fact that the Pisuerga runs through Valladolid…

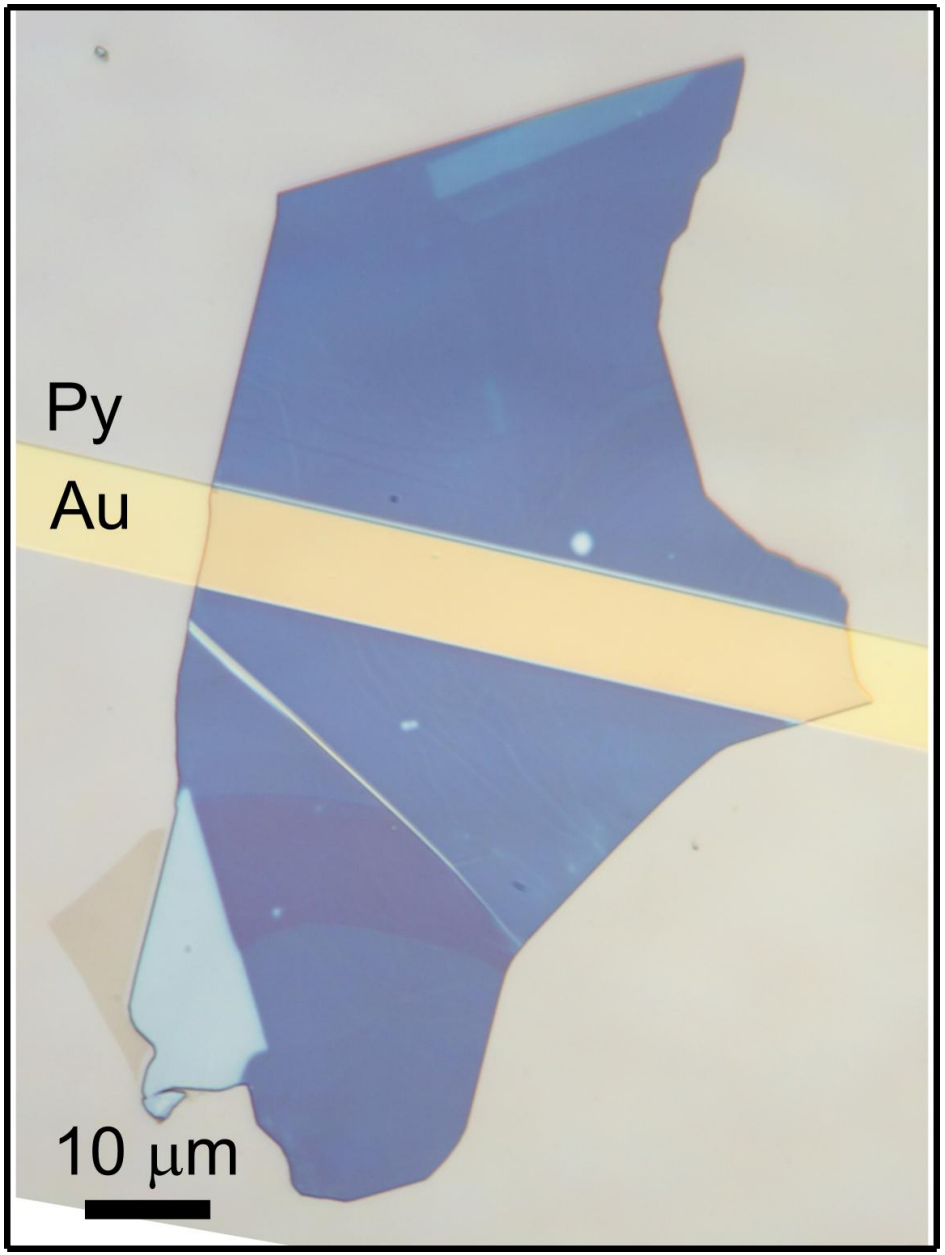
For Today



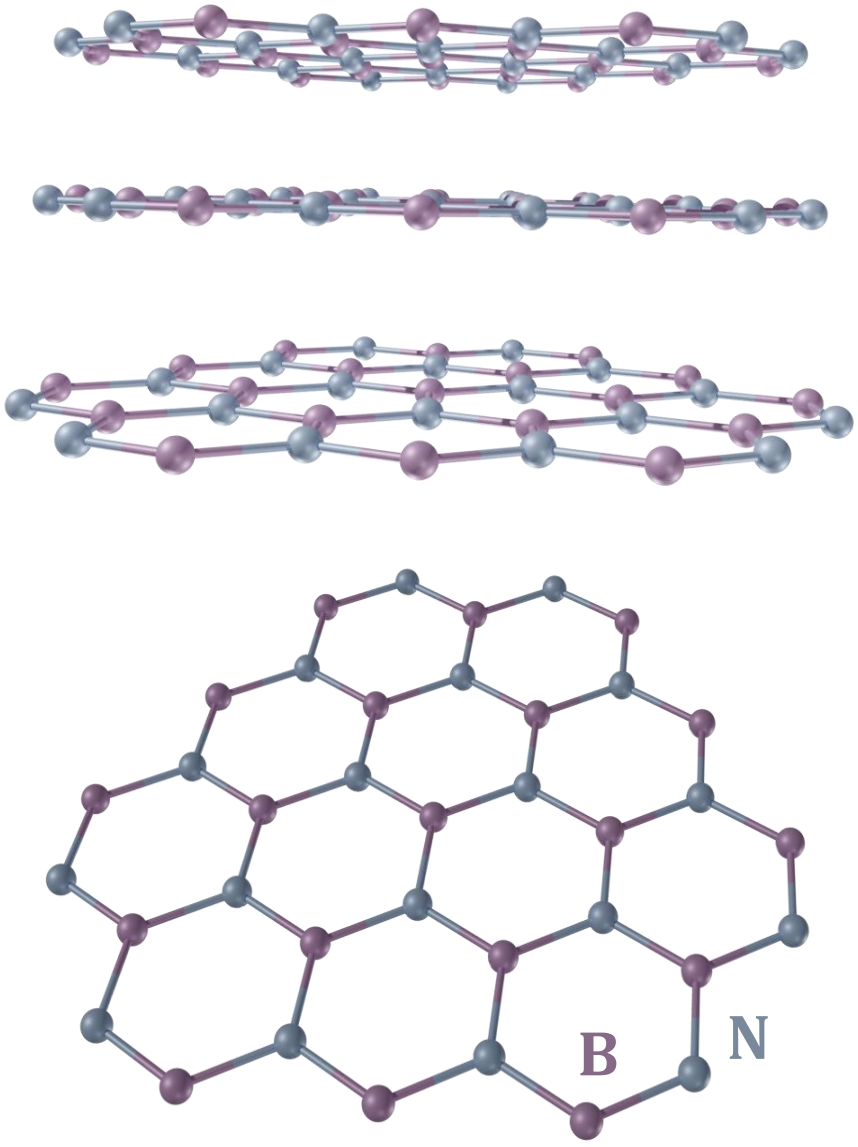




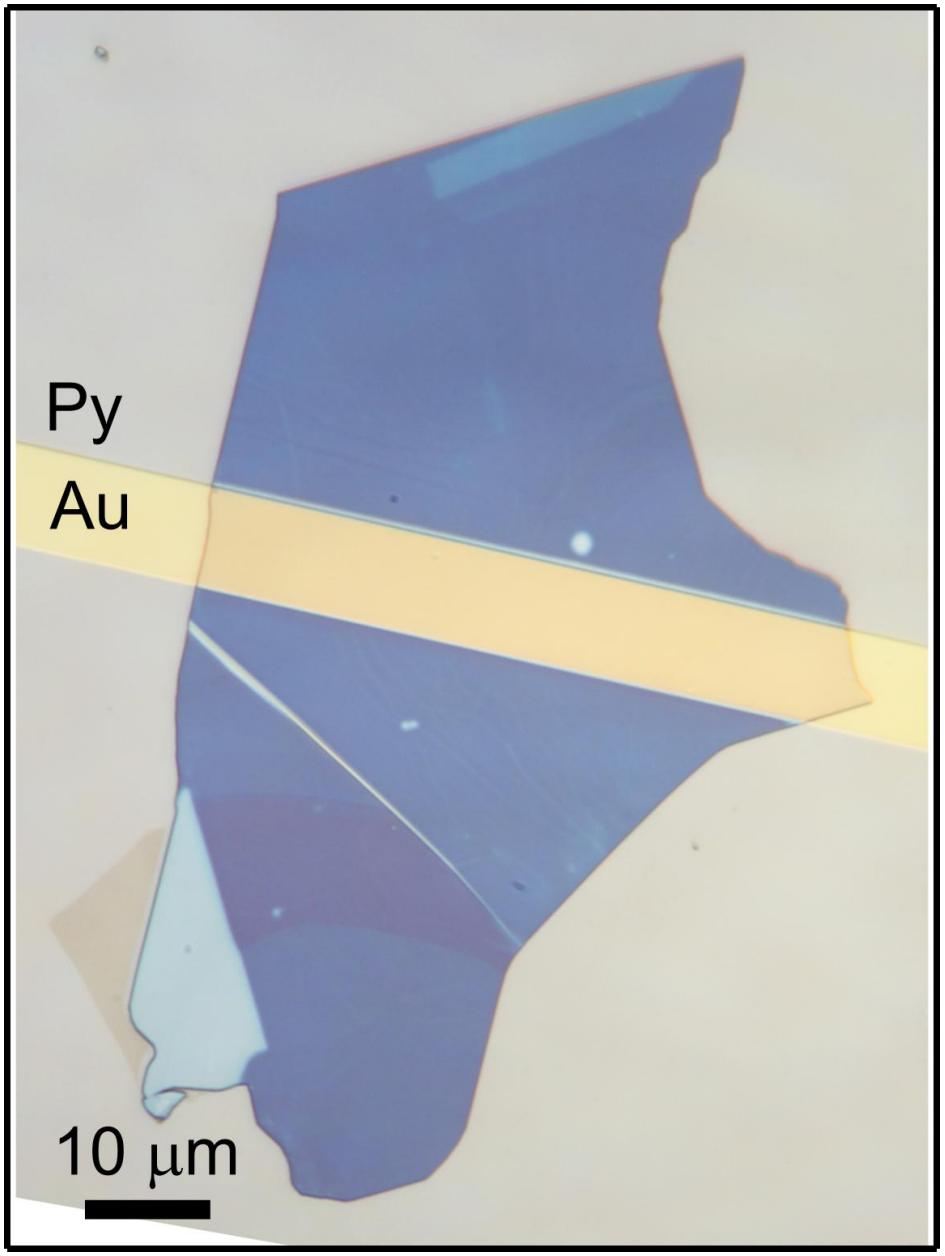
For Today



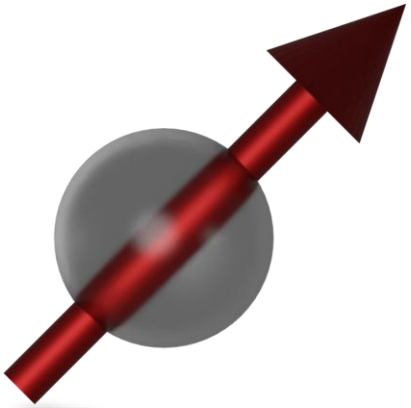
hexagonal Boron Nitride

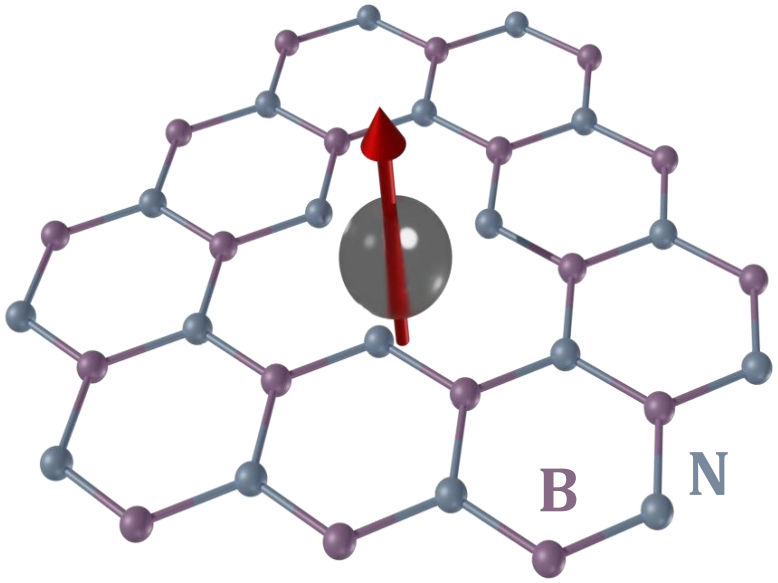


For Today

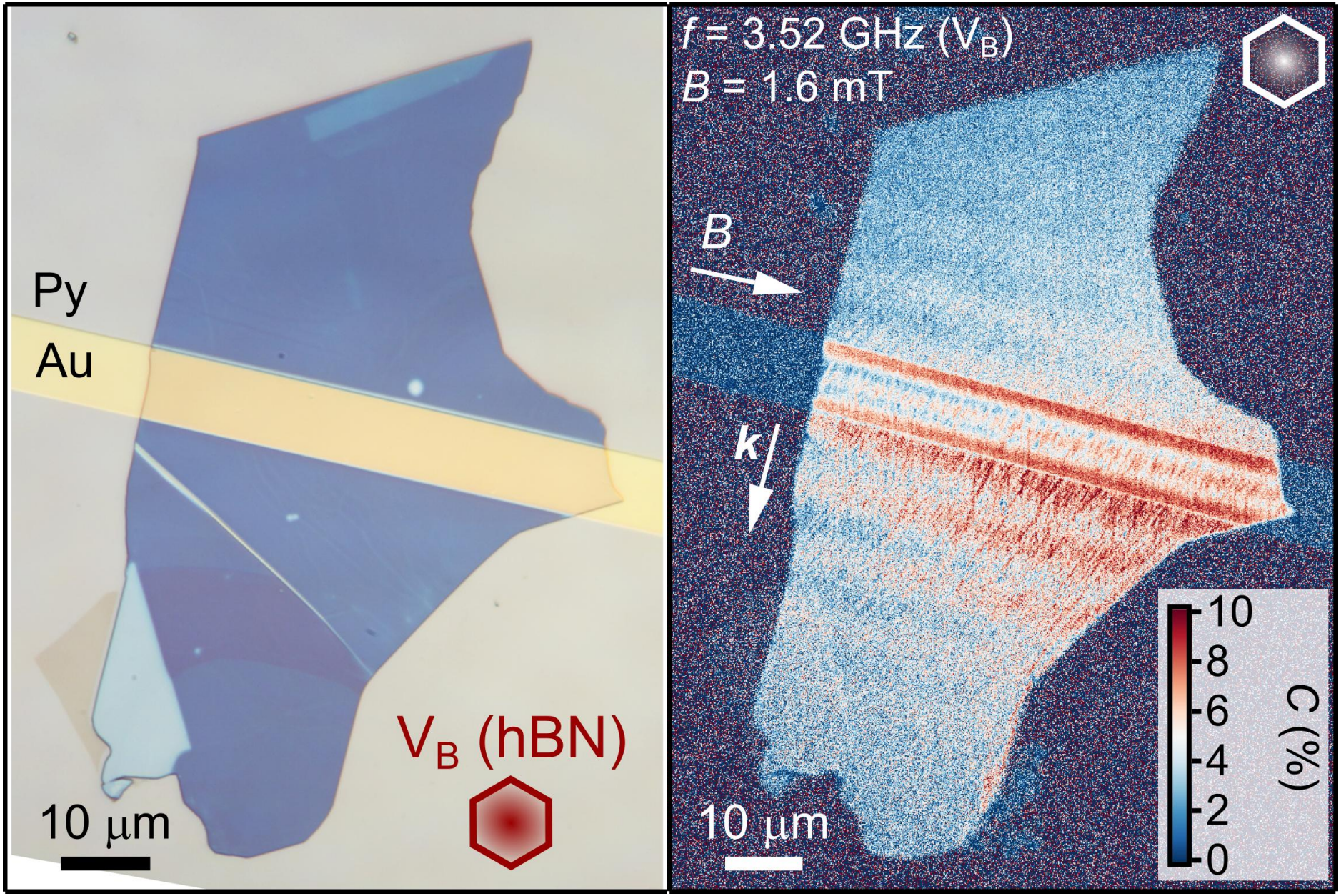


Spin defects





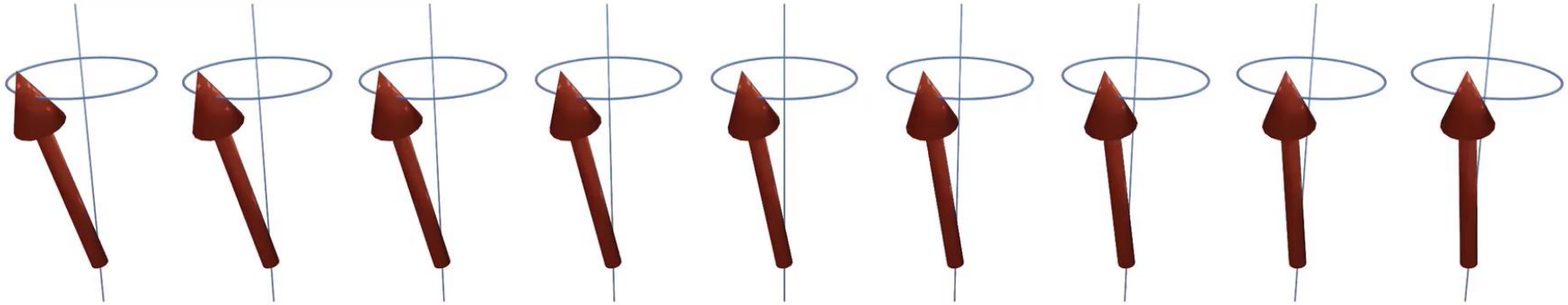
For Today



Dynamic magnetization

Ferromagnetic resonance (FMR): $\vec{k} = 0$

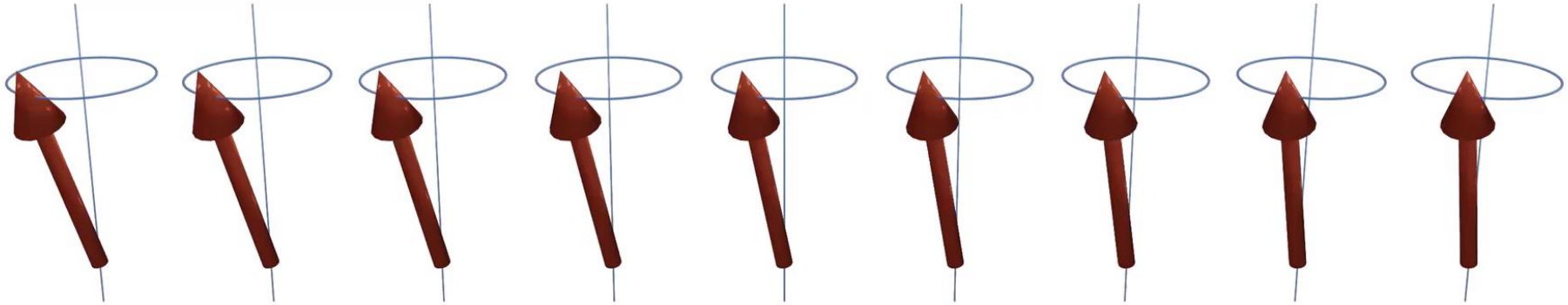
All spins in-phase



Dynamic magnetization

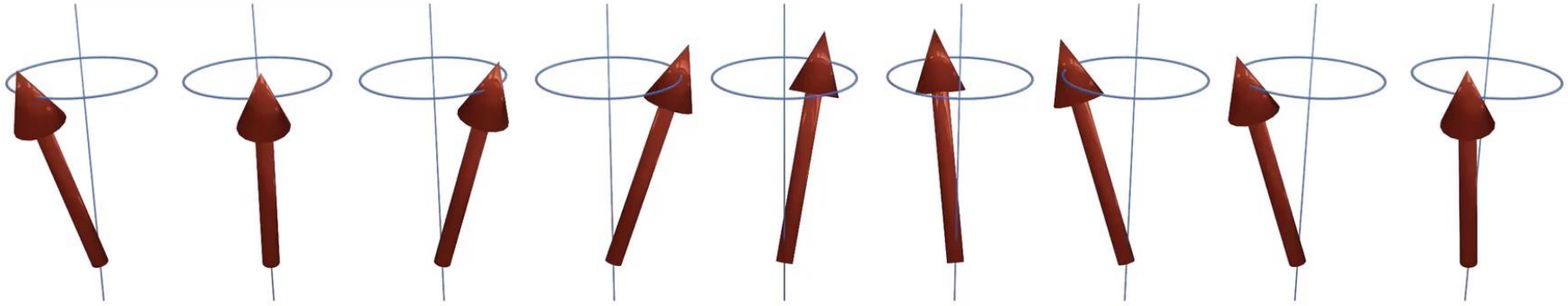
Ferromagnetic resonance (FMR): $\vec{k} = 0$

All spins in-phase



Spin waves with finite $\vec{k}$

Dephasing between spins

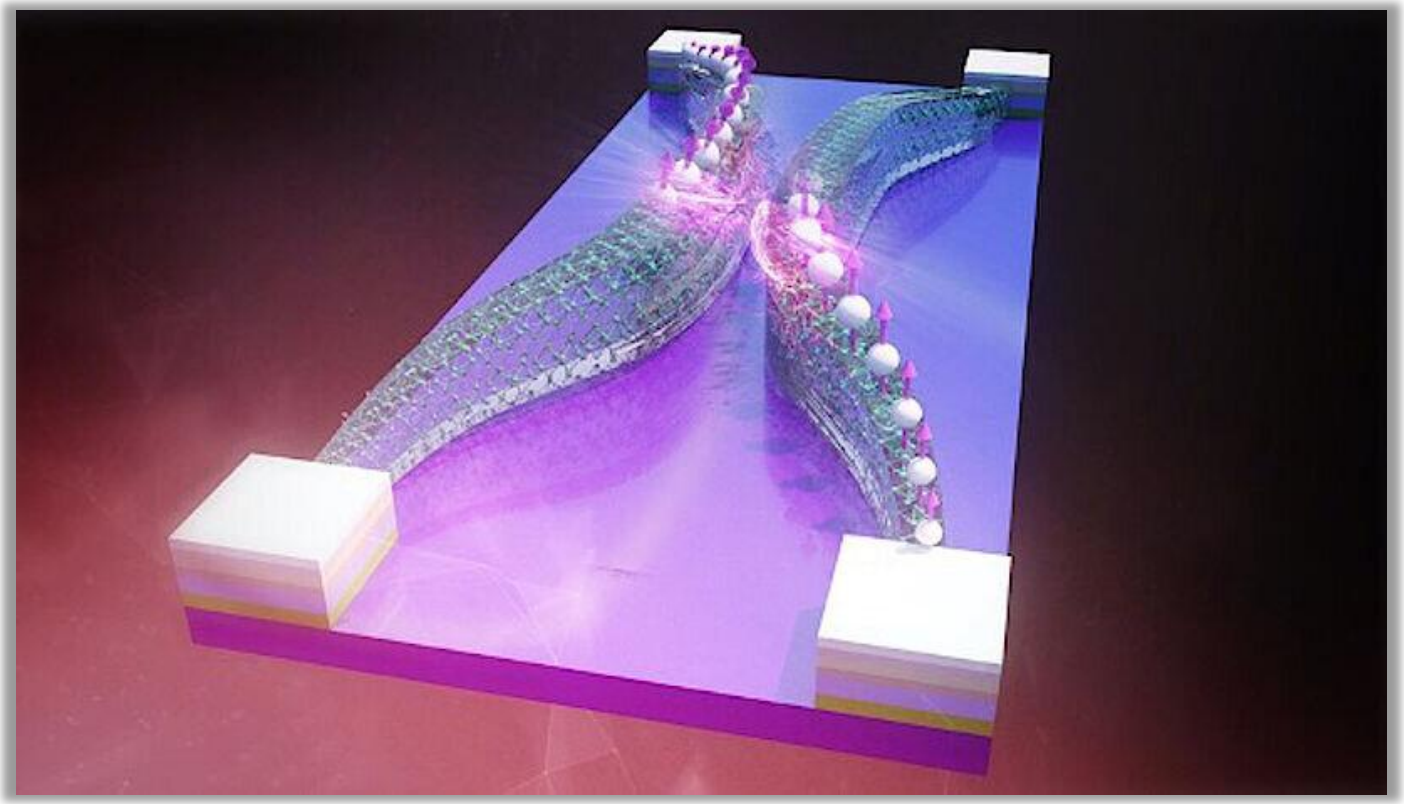




Magnon spintronics

Goal:

replacing electric currents by spin currents



Nat. Electronics 3, 765, 2020

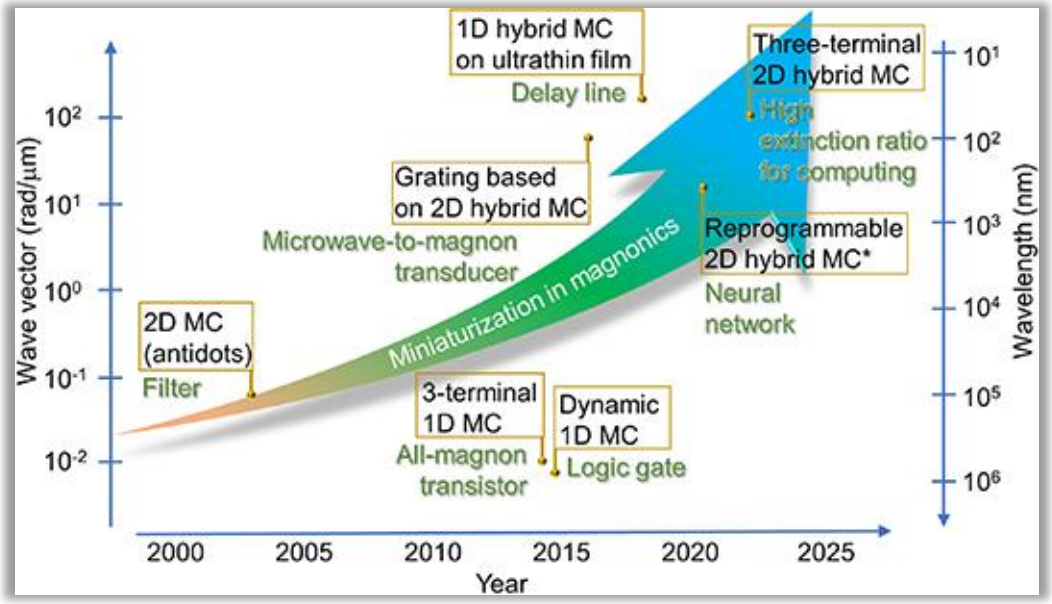
Magnon spintronics

Goal:

replacing electric currents by spin currents

Challenge:

miniaturization



The 2024 magnonics roadmap,
J. Phys.: Condens. Matter
36 363501, 2024

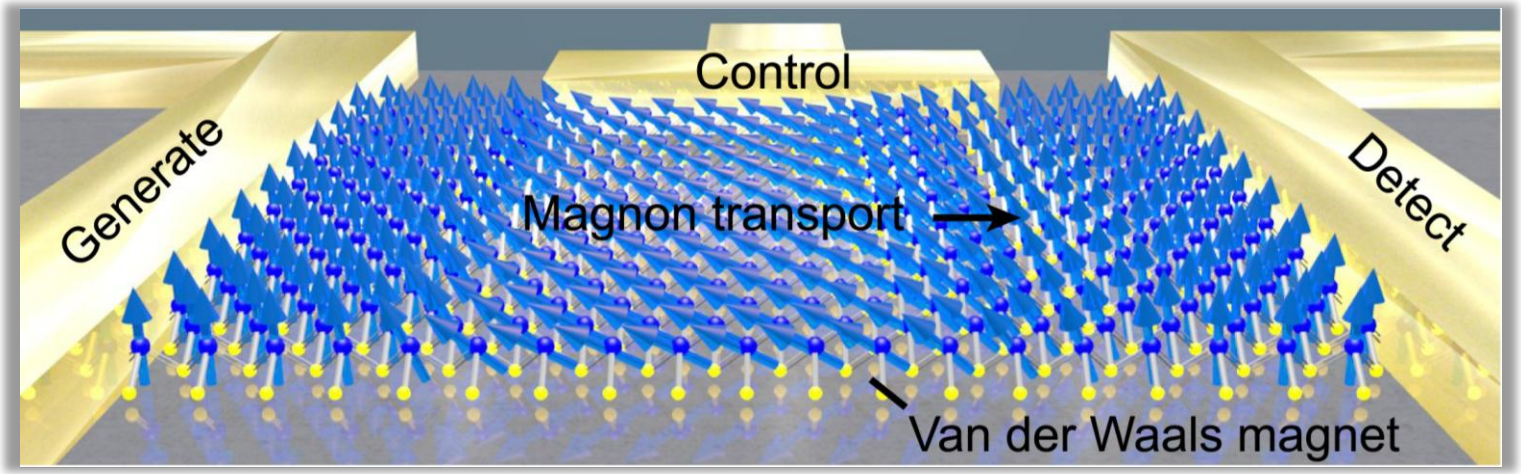
van der Waals magnets for magnon spintronics

Goal:

replacing electric currents by spin currents

Challenge:
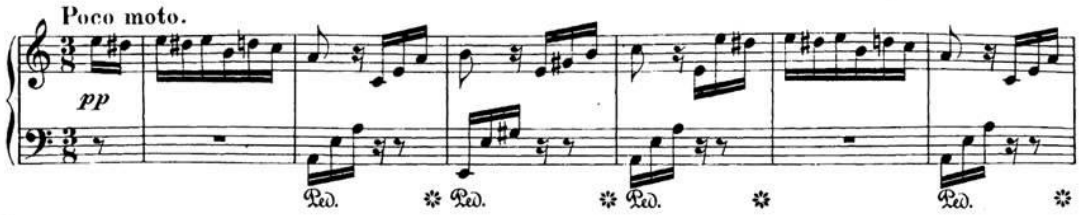
miniaturization

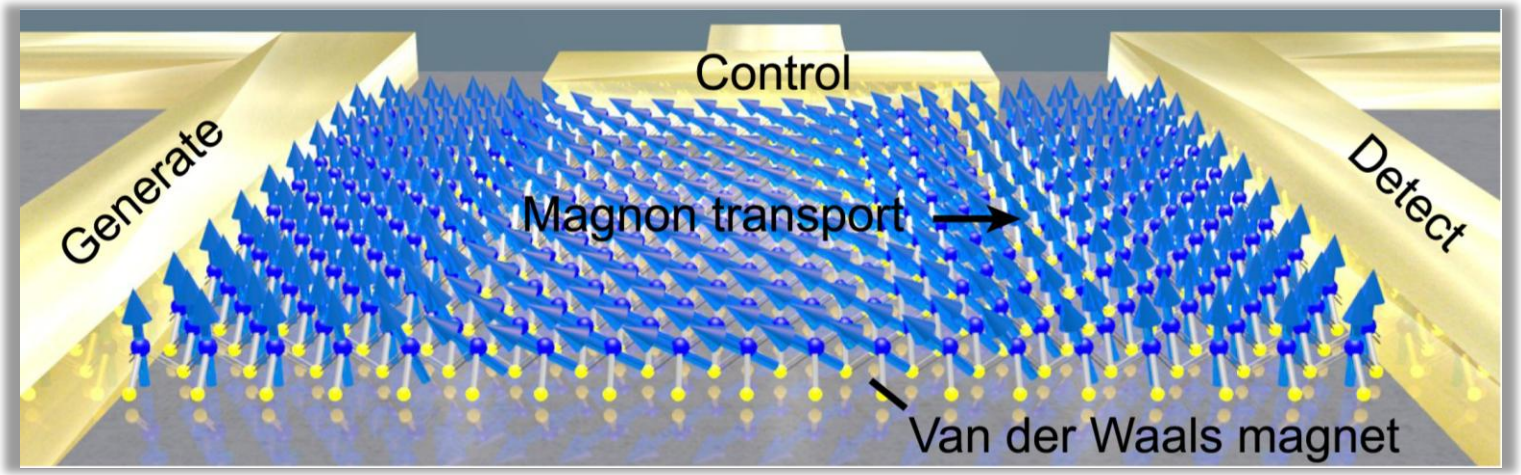


Mañas-Valero, van der Sar, Duine, van Wees, Newton 1, 1, 100018, 2025

A very simple *magnonic* device

1. ***Generate f (typically, GHz regime)***

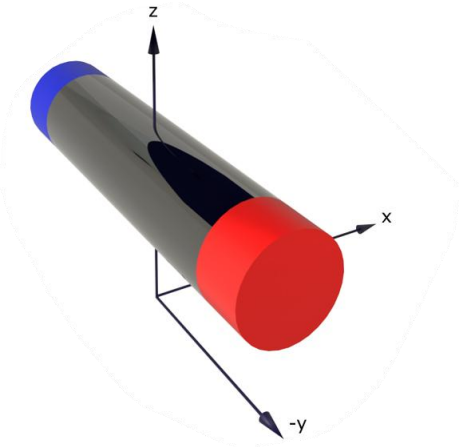


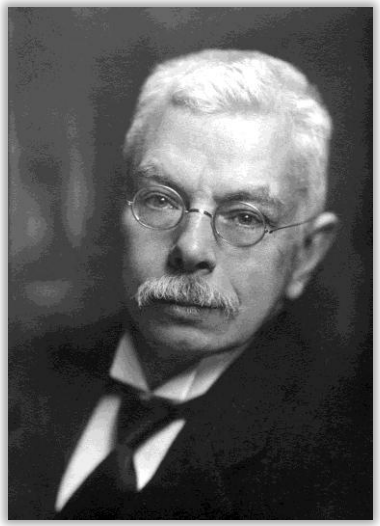


Mañas-Valero, van der Sar, Duine, van Wees, Newton 1, 1, 100018, 2025

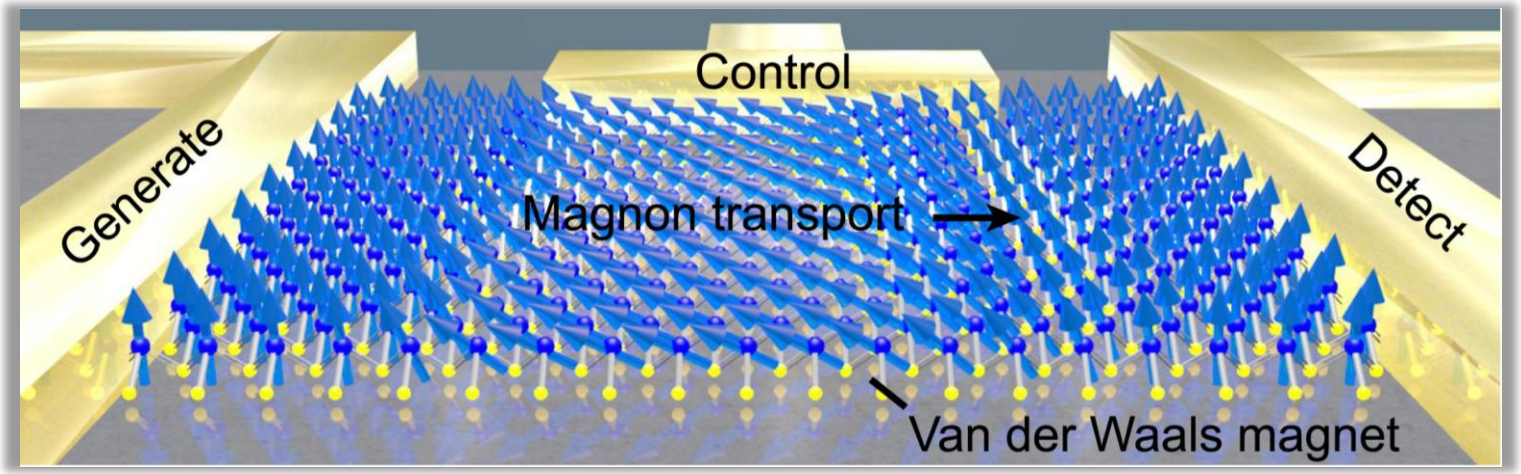
A very simple *magnonic* device

1. ***Generate***
2. ***Control***





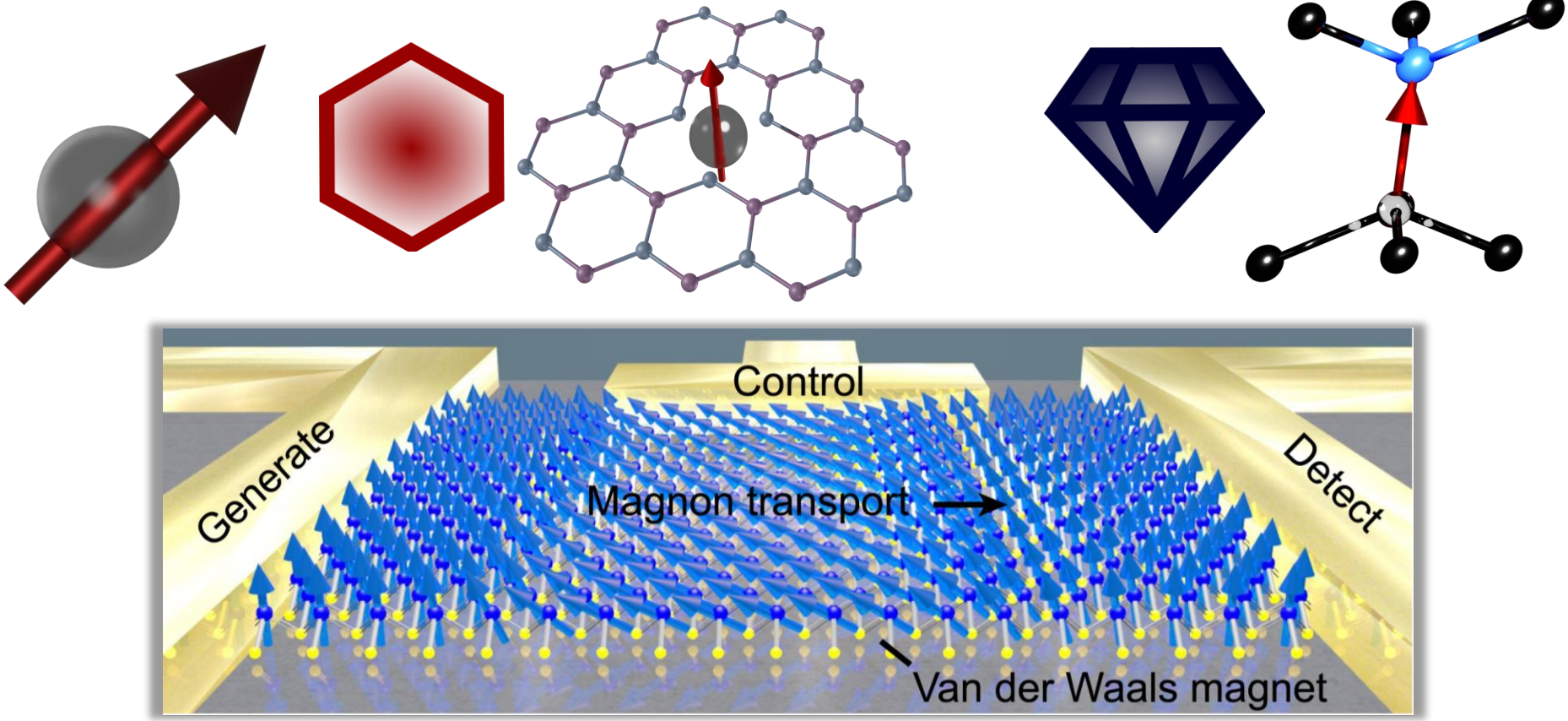
Zeeman
(1865 - 1943)



Mañas-Valero, van der Sar, Duine, van Wees, Newton 1, 1, 100018, 2025

A very simple *magnonic* device

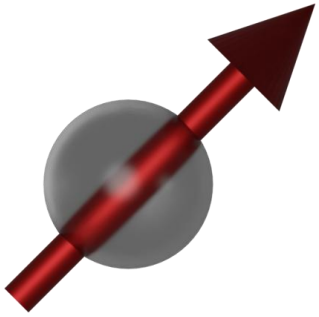
1. ***Generate***
2. ***Control***
3. ***Detect: quantum sensing with solid-state spin defects***

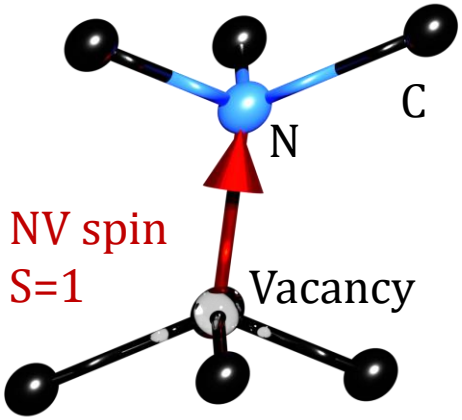


Mañas-Valero, van der Sar, Duine, van Wees, Newton 1, 1, 100018, 2025

Quantum sensing with color centers

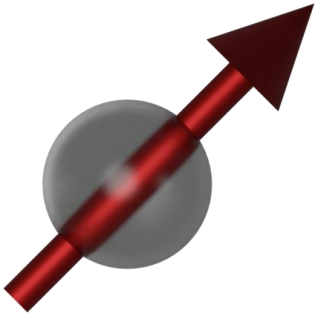
Nitrogen-Vacancy
(NV) center in diamond

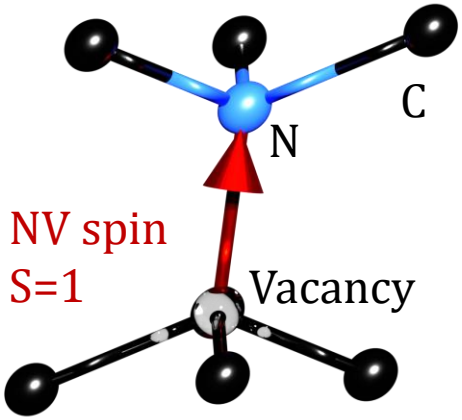




Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond

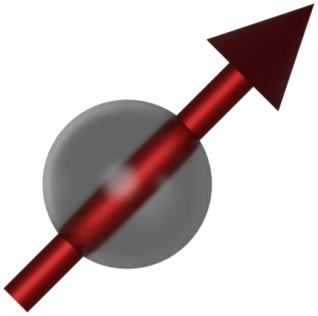


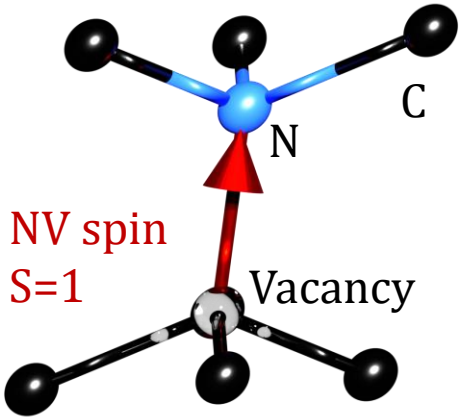


Optically Detected Magnetic Resonance (ODMR)

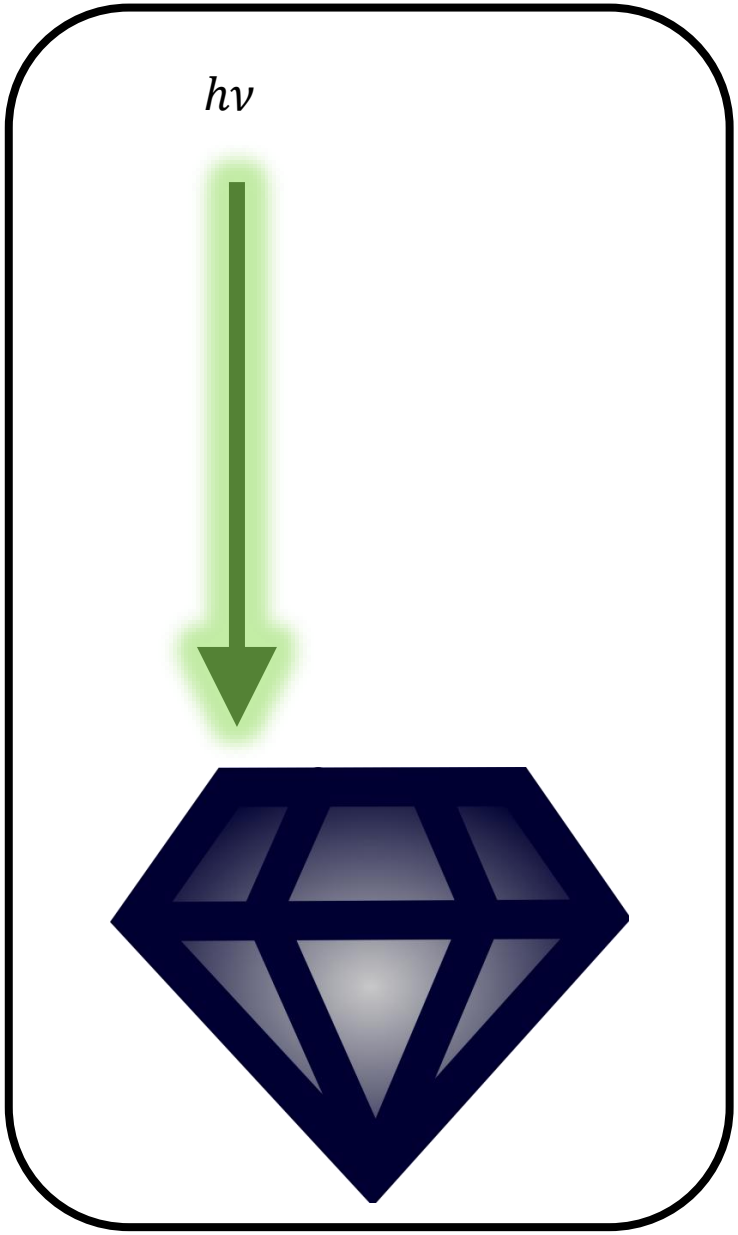
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond



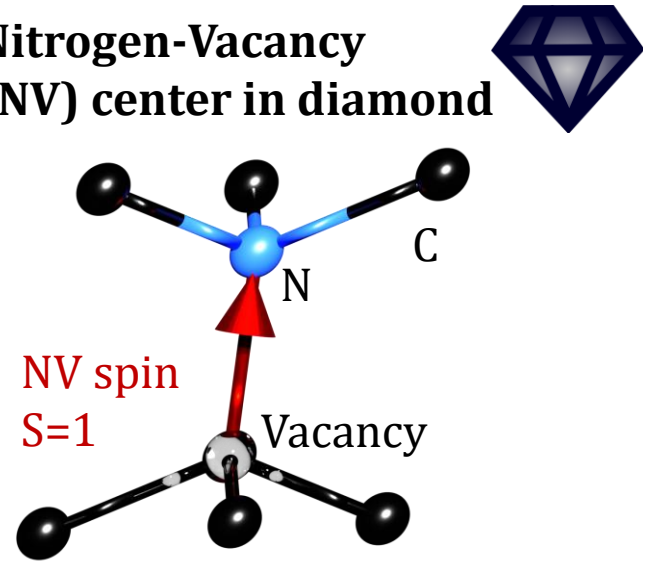


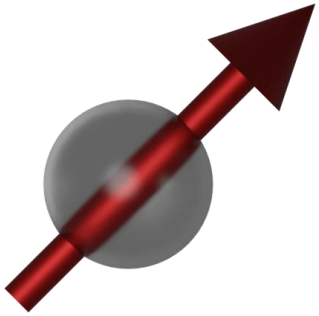
Optically Detected Magnetic Resonance (ODMR)



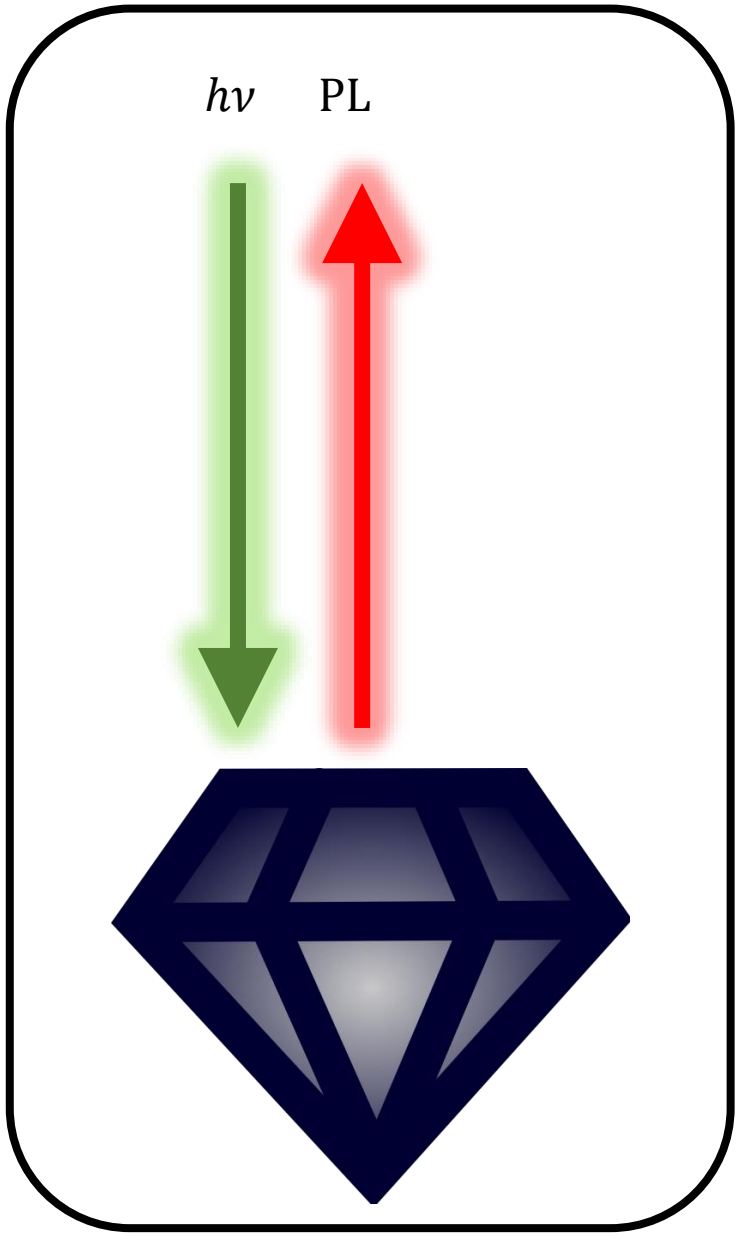
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond

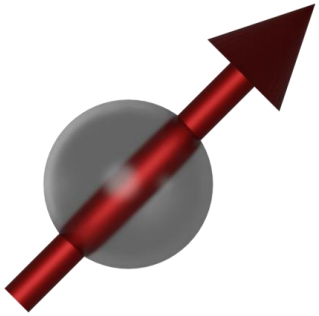




Optically Detected Magnetic Resonance (ODMR)

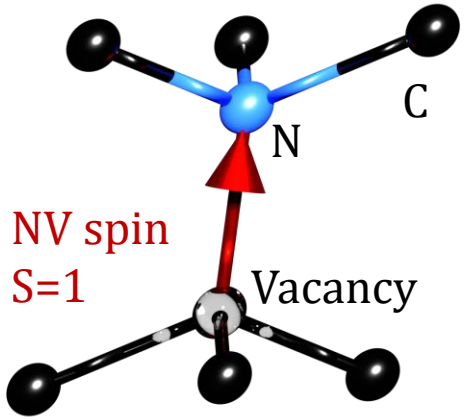


Quantum sensing with color centers

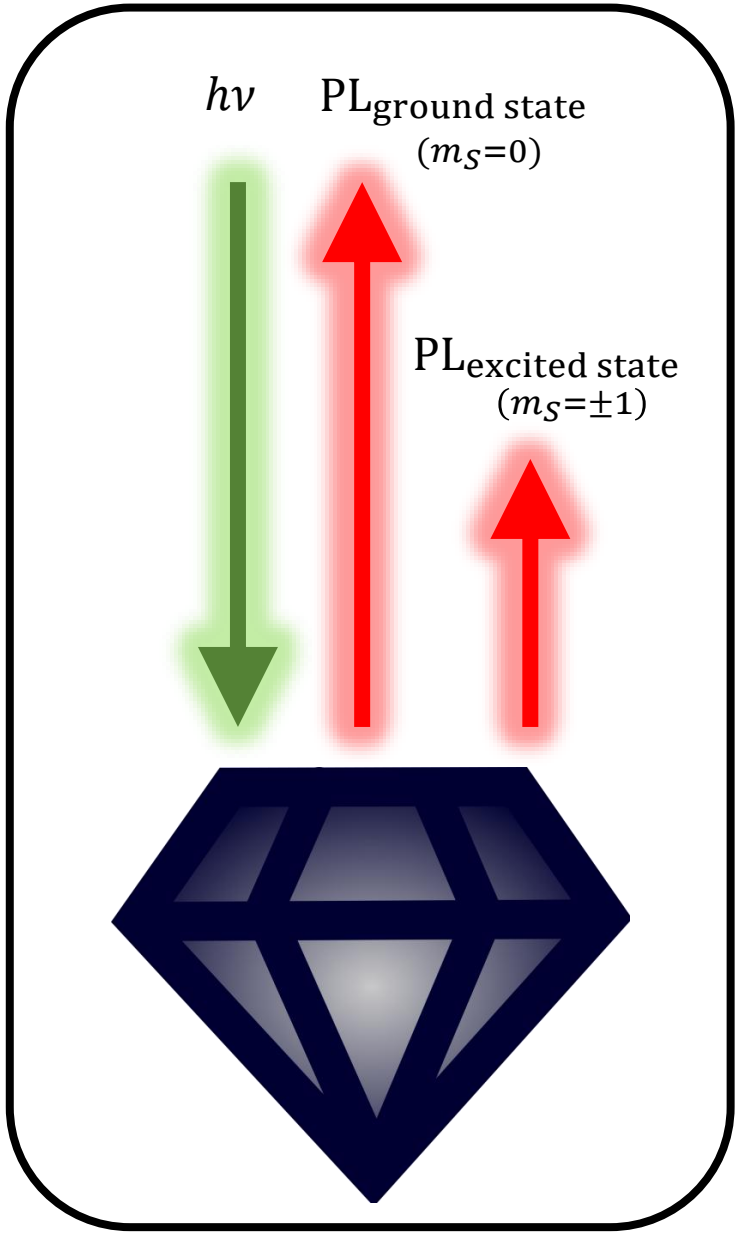


Nitrogen-Vacancy (NV) center in diamond

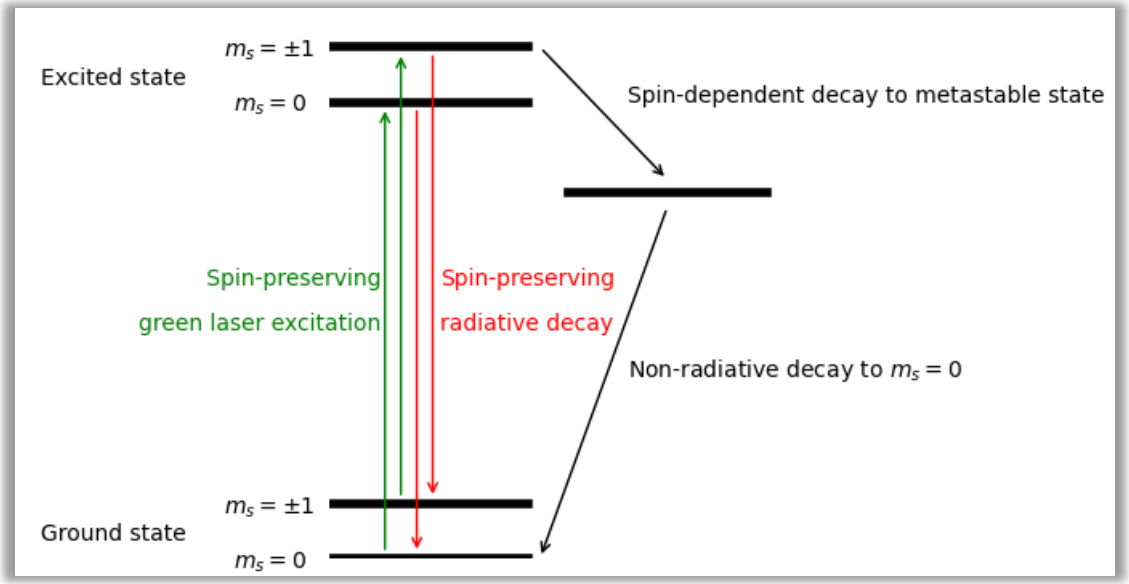


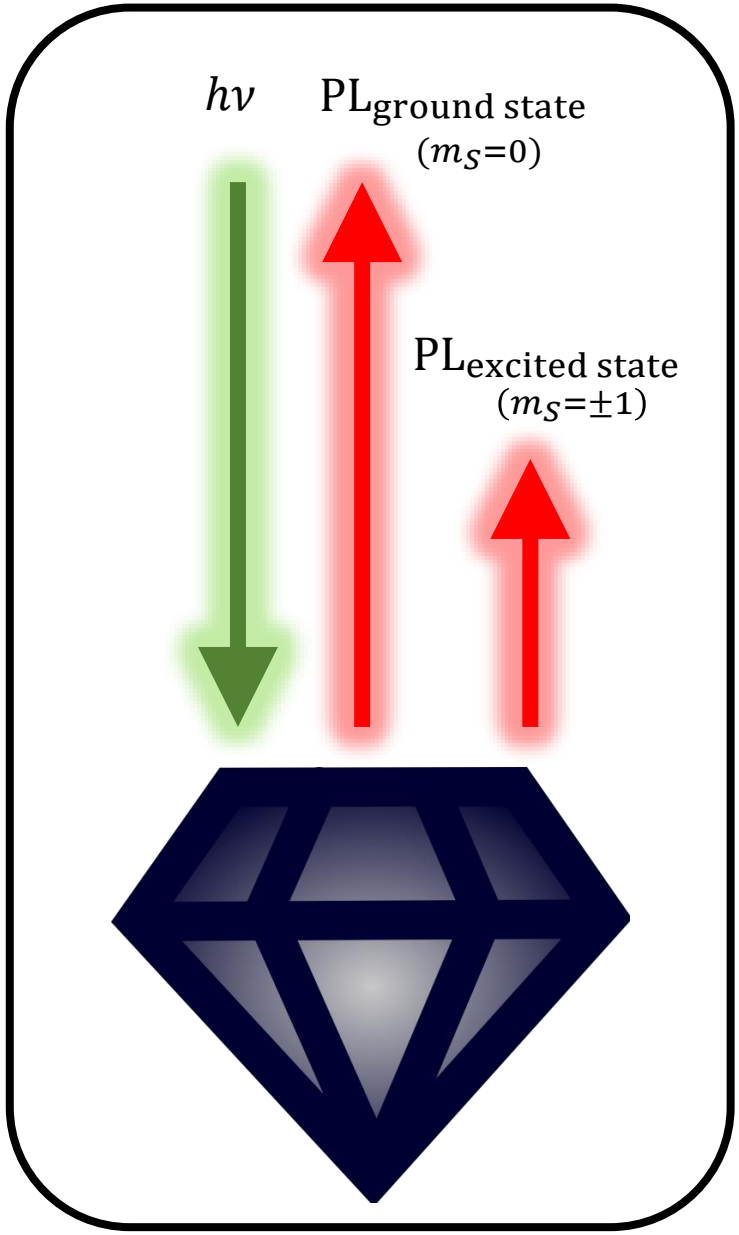


Optically Detected Magnetic Resonance (ODMR)



Quantum sensing with color centers



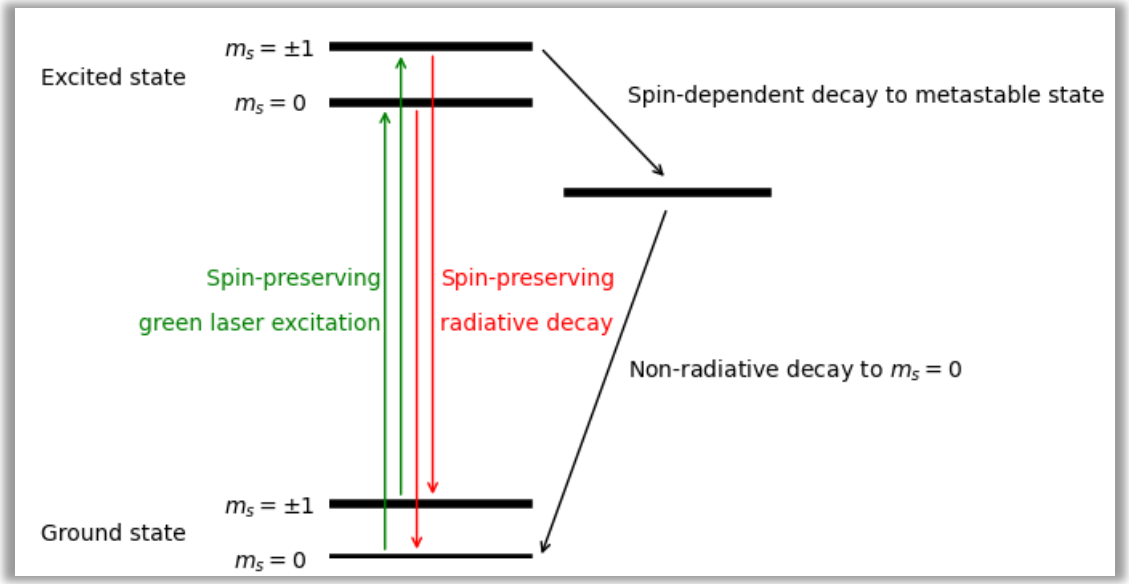


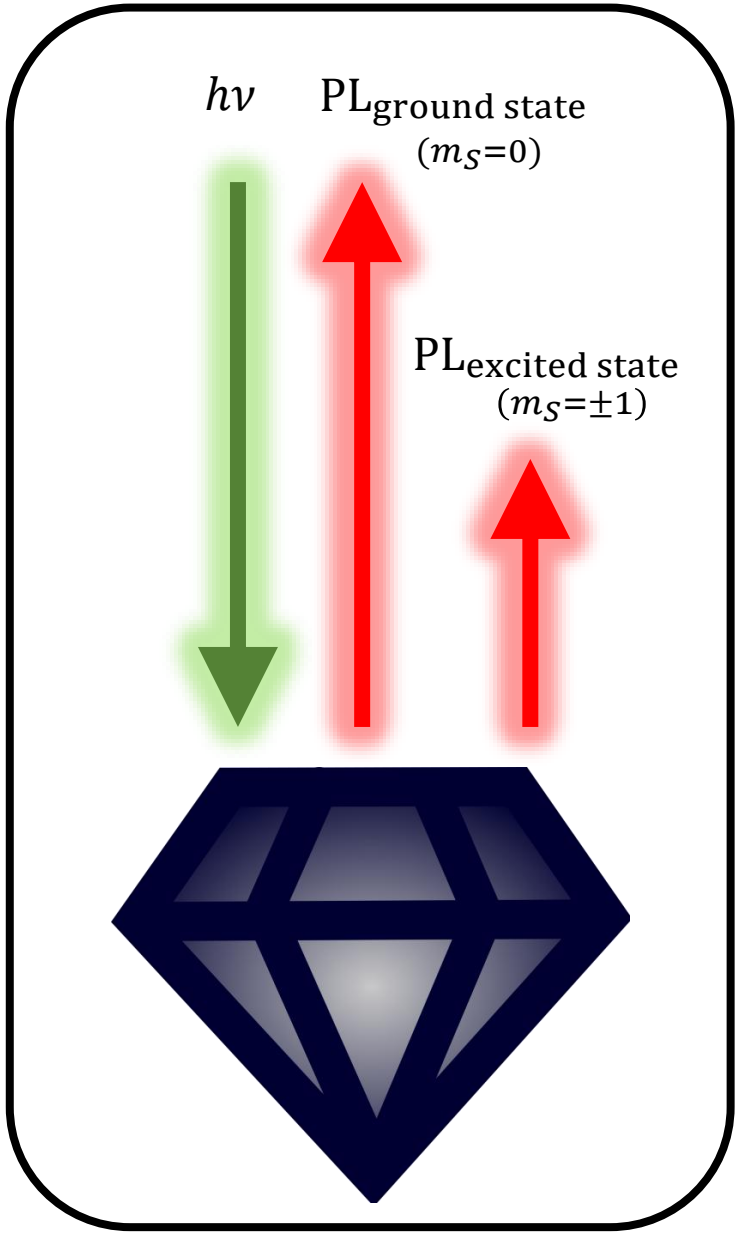
Optically Detected Magnetic Resonance (ODMR)

Green laser illumination continuously polarize the electron spins to the sublevel $|m_s=0>$, which enables optical initialization of the spin state.

The intensity of the PL is lower for the $|m_s=\pm 1>$ states due to a spin-selective, non-radiative decay channel.

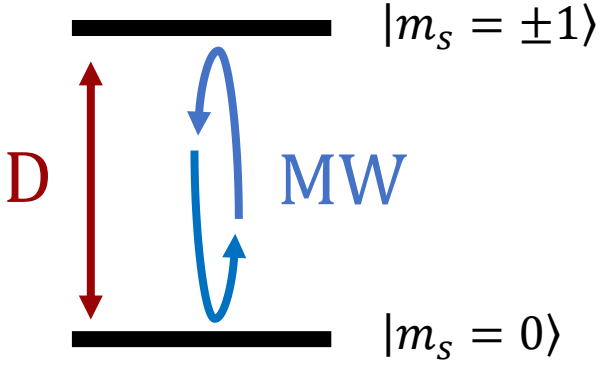
Quantum sensing with color centers





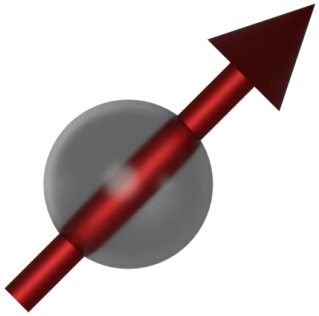
Optically Detected Magnetic Resonance (ODMR)

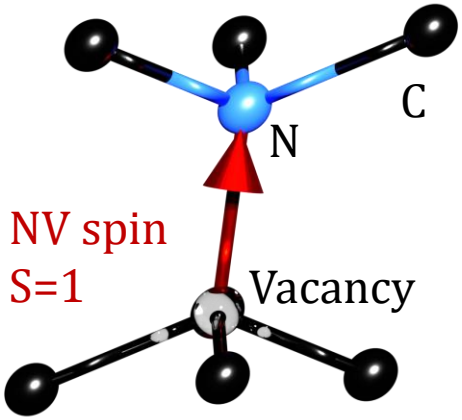
We can drive the NV between $|m_s = 0\rangle$ and $|m_s = \pm 1\rangle$ with microwave pulses!



Quantum sensing with color centers

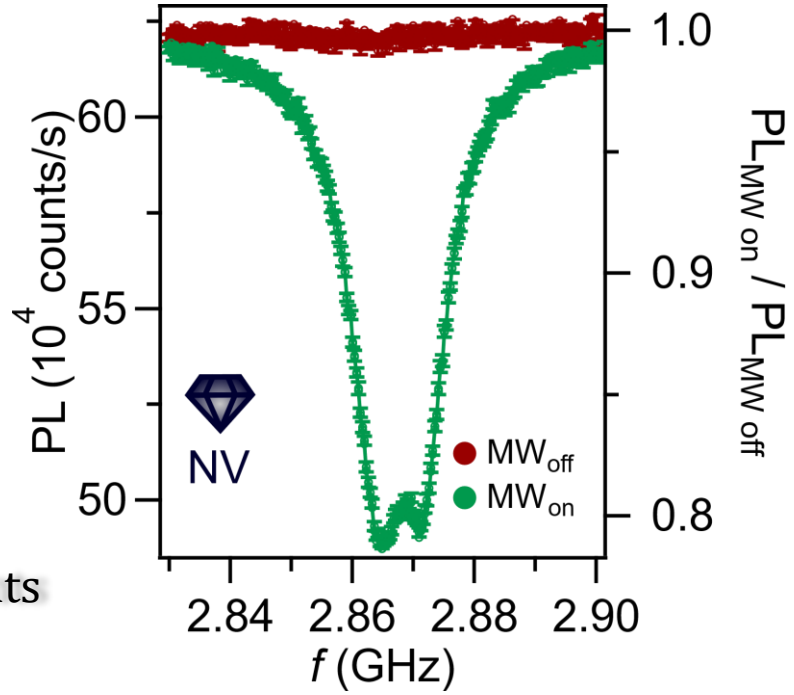
Nitrogen-Vacancy (NV) center in diamond





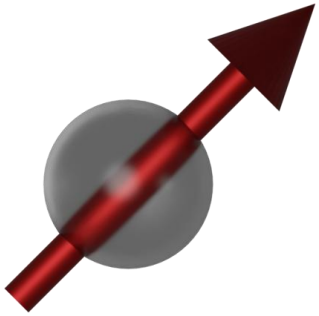
Optically Detected Magnetic Resonance (ODMR)

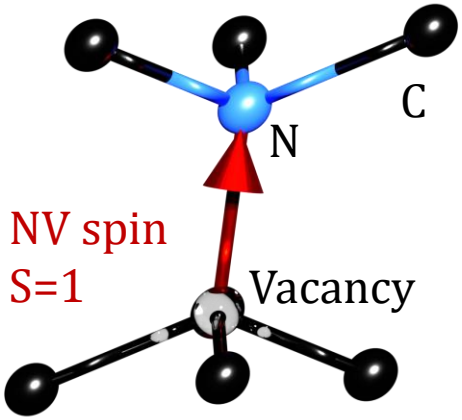
Zero-Field measurements



Quantum sensing with color centers

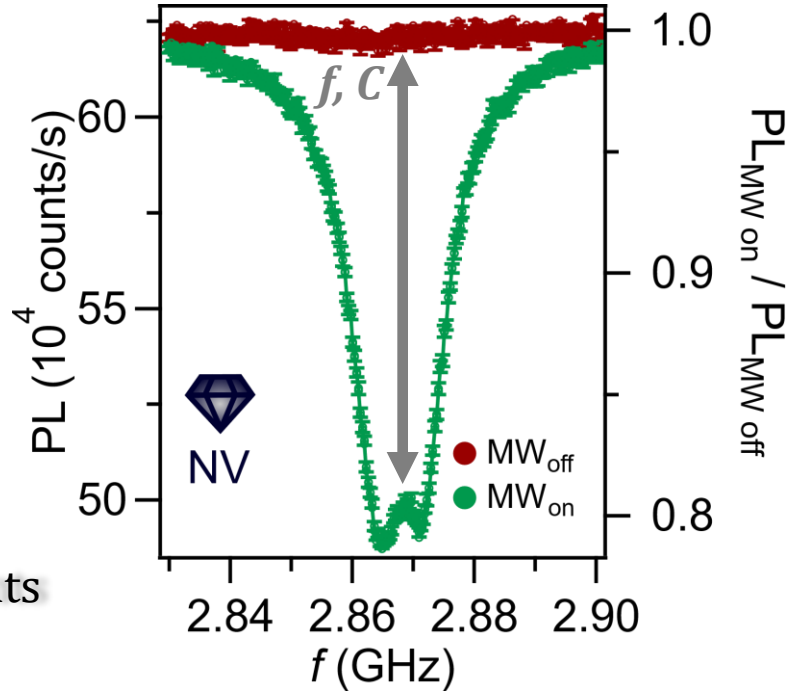
Nitrogen-Vacancy (NV) center in diamond





Optically Detected Magnetic Resonance (ODMR)

Zero-Field measurements

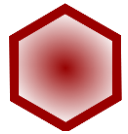


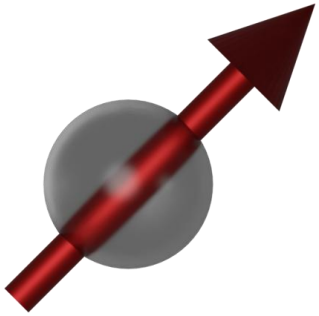
Quantum sensing with color centers

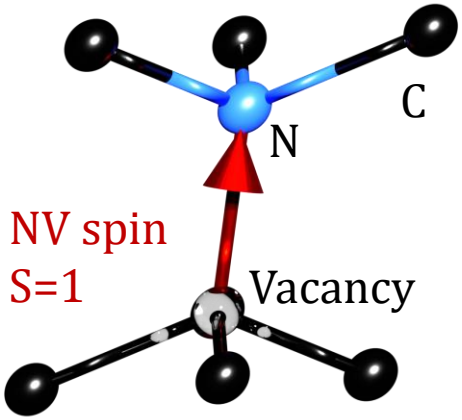
Nitrogen-Vacancy (NV) center in diamond

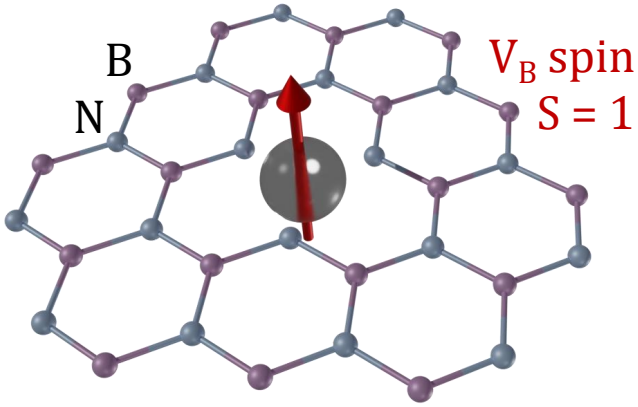


Boron Vacancy in hBN (van der Waals material)



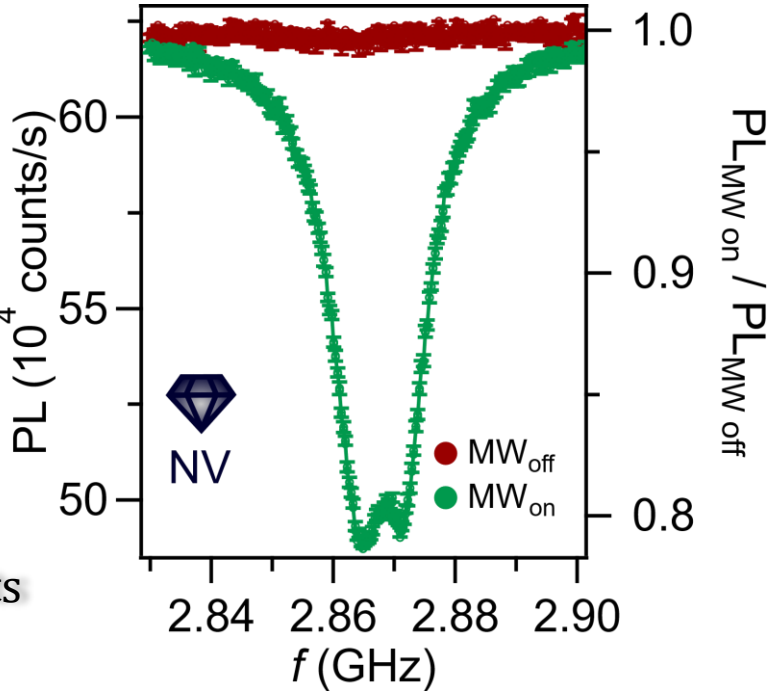


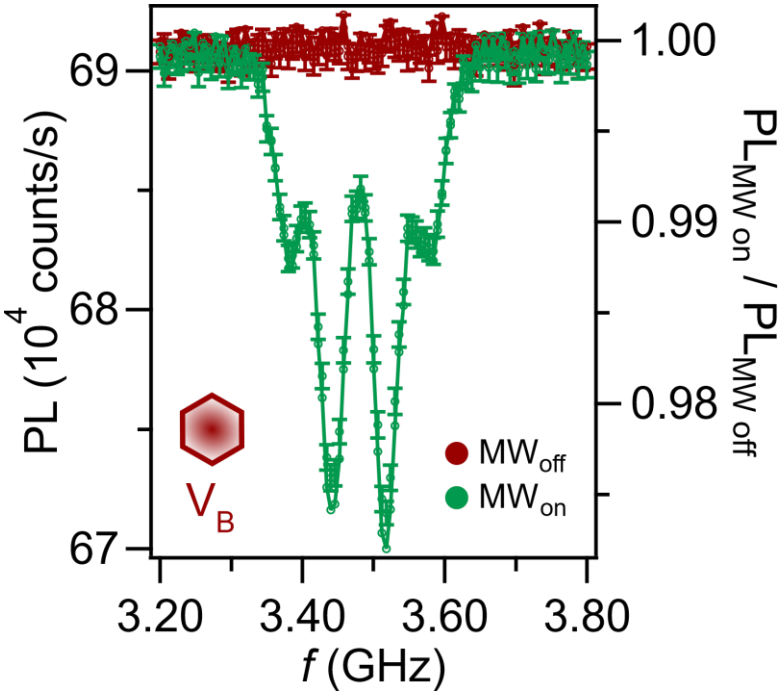




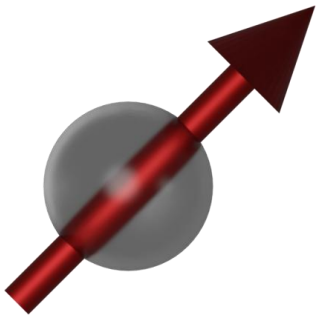
Optically Detected Magnetic Resonance (ODMR)

Zero-Field measurements

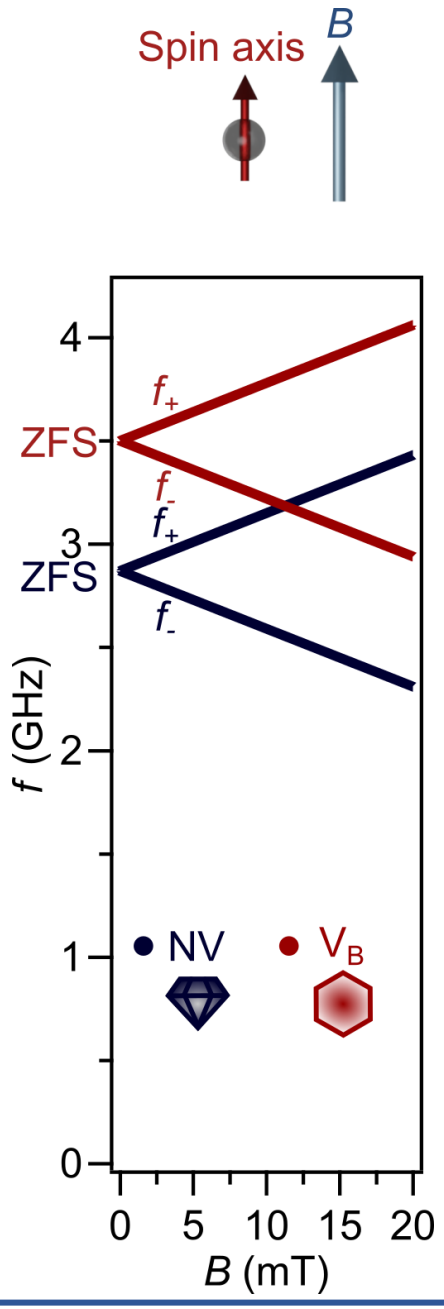




Quantum sensing with color centers

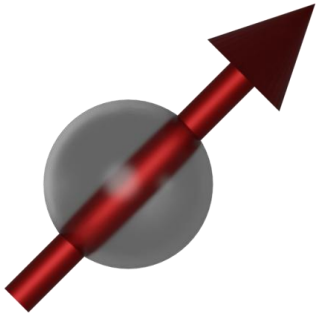


Magnetometry

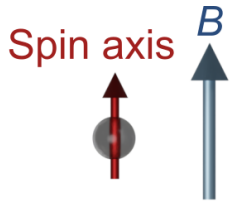


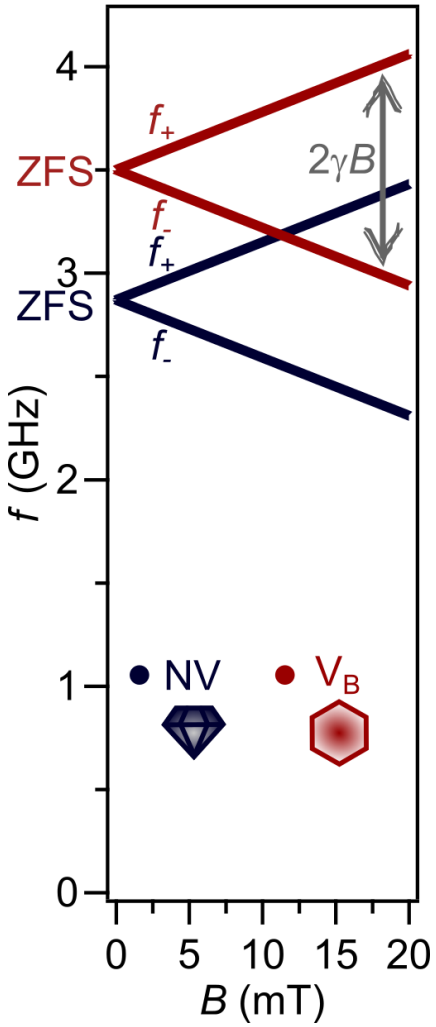
Why *colors*?

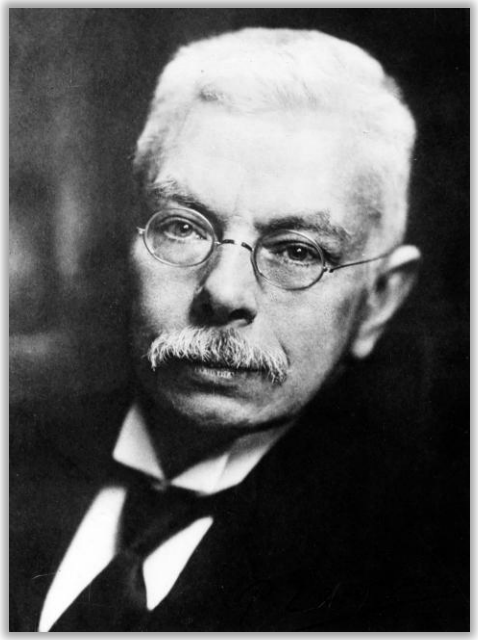
Color center magnetometry



Magnetometry

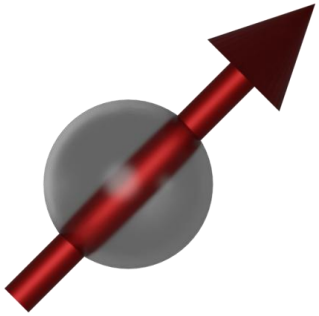


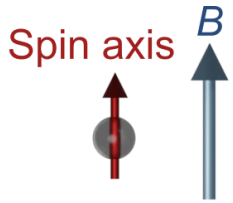




Pieter Zeeman
(1865-1943)

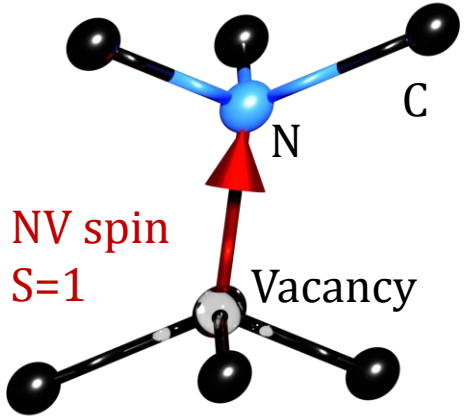
Color center magnetometry

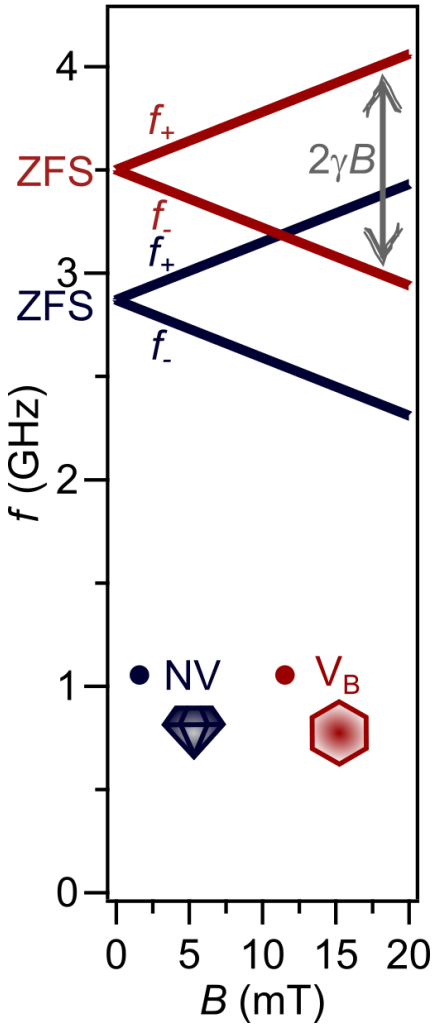




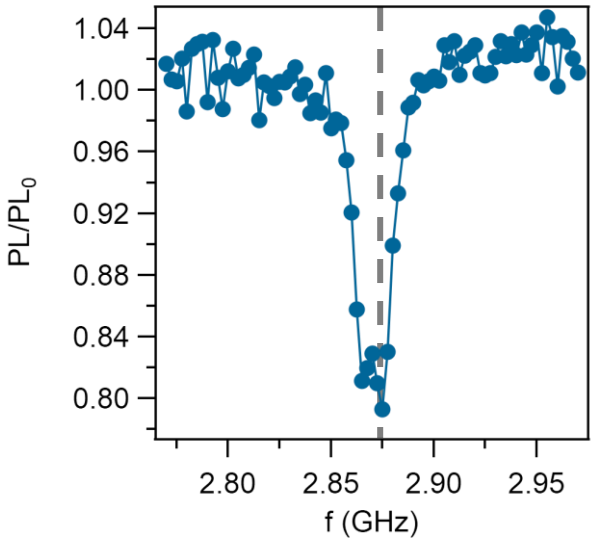
Nitrogen-Vacancy (NV) center in diamond



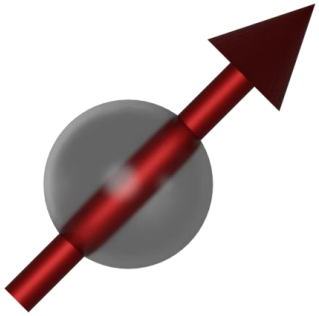




B = 0

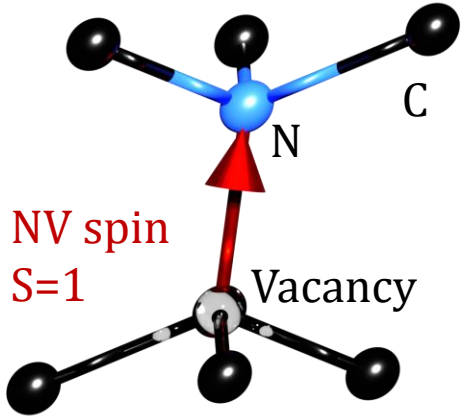


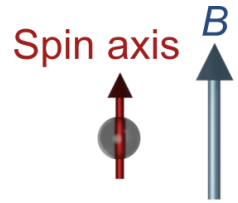
Color center magnetometry

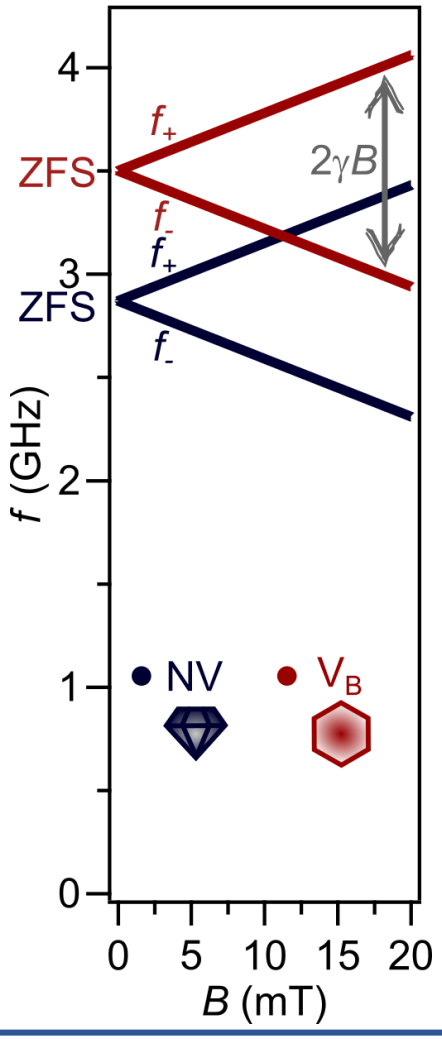


Nitrogen-Vacancy (NV) center in diamond

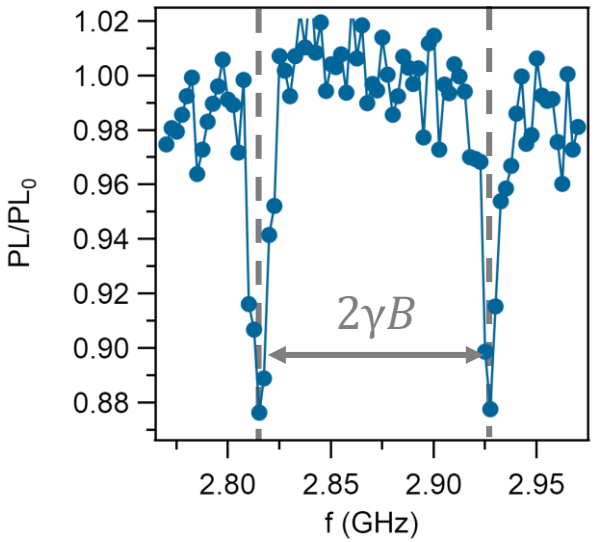




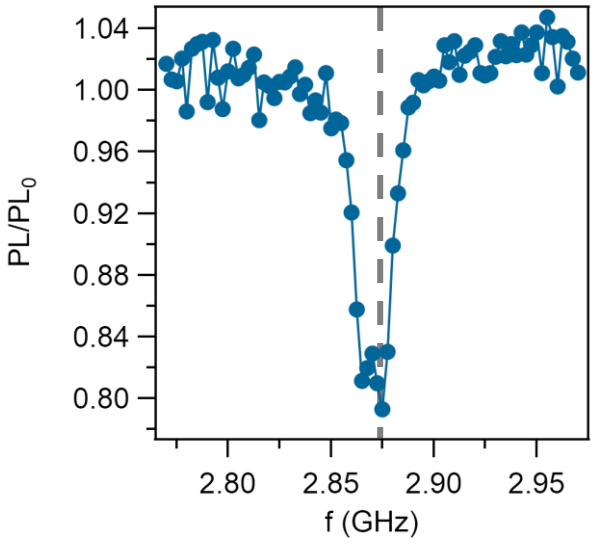




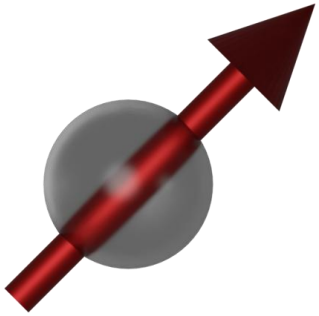
$B \neq 0$



$B = 0$

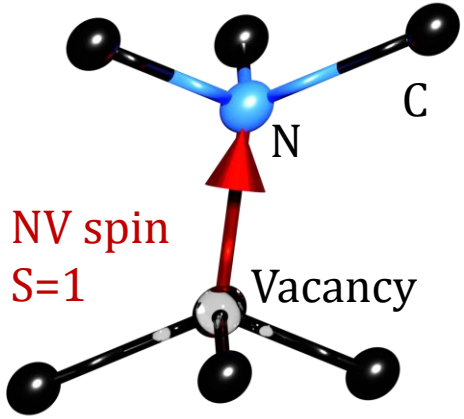


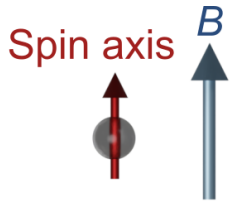
Color center magnetometry

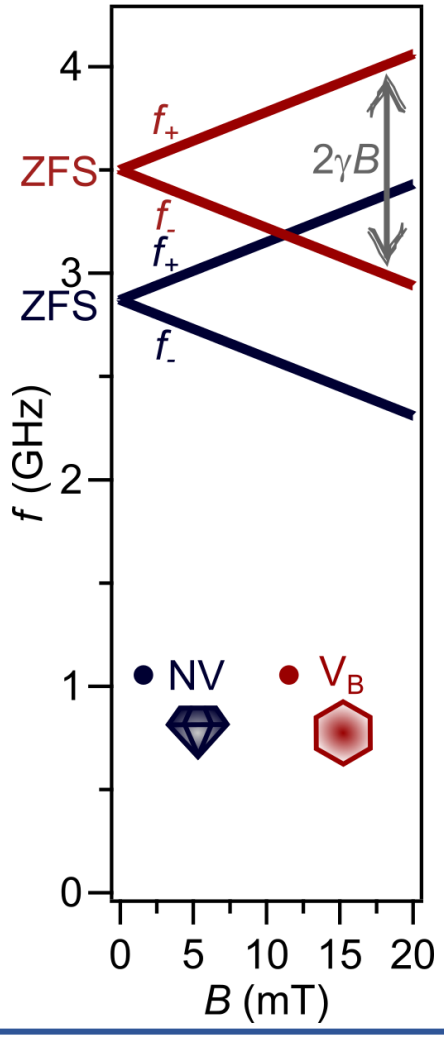


Nitrogen-Vacancy (NV) center in diamond



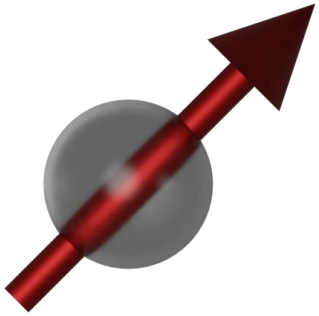




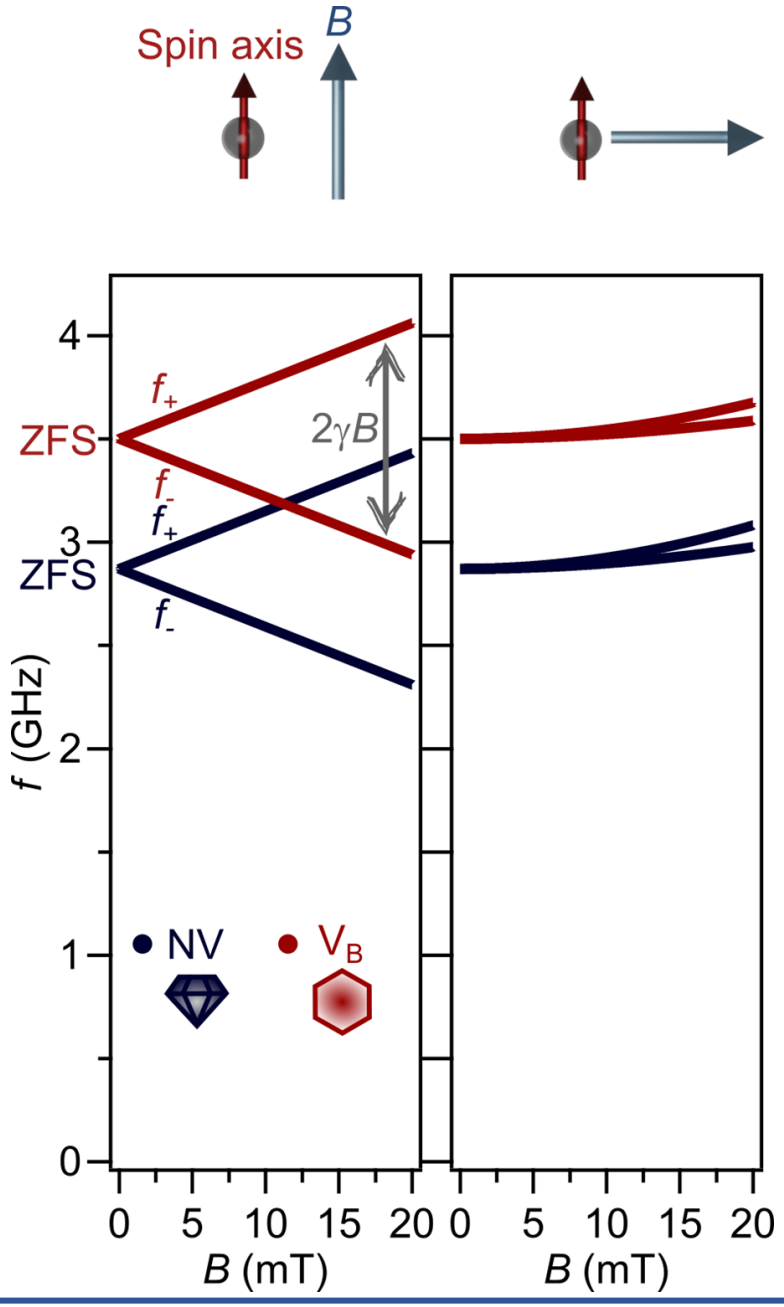


Resonance frequency depends on magnetic field

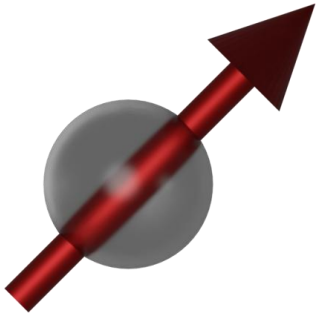
Color center magnetometry for spin-wave imaging



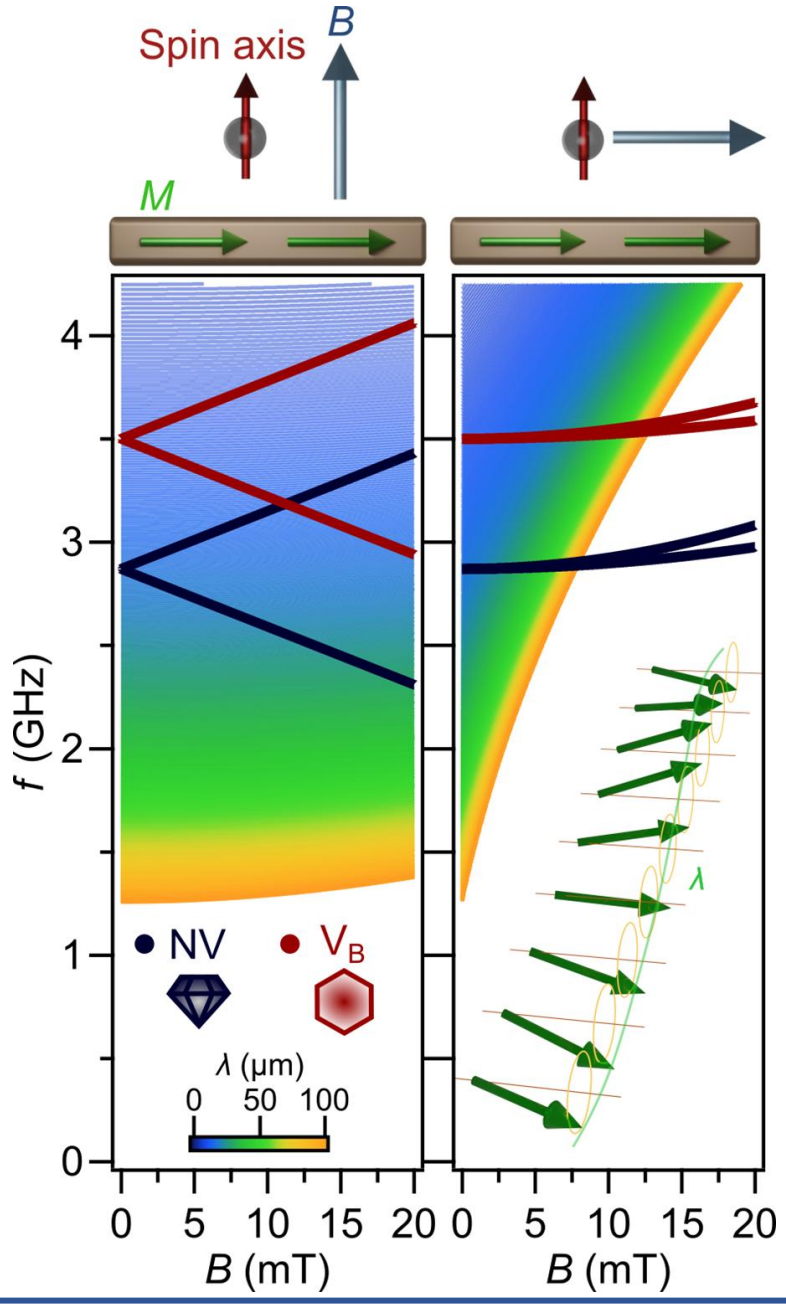
Isofrequency measurements



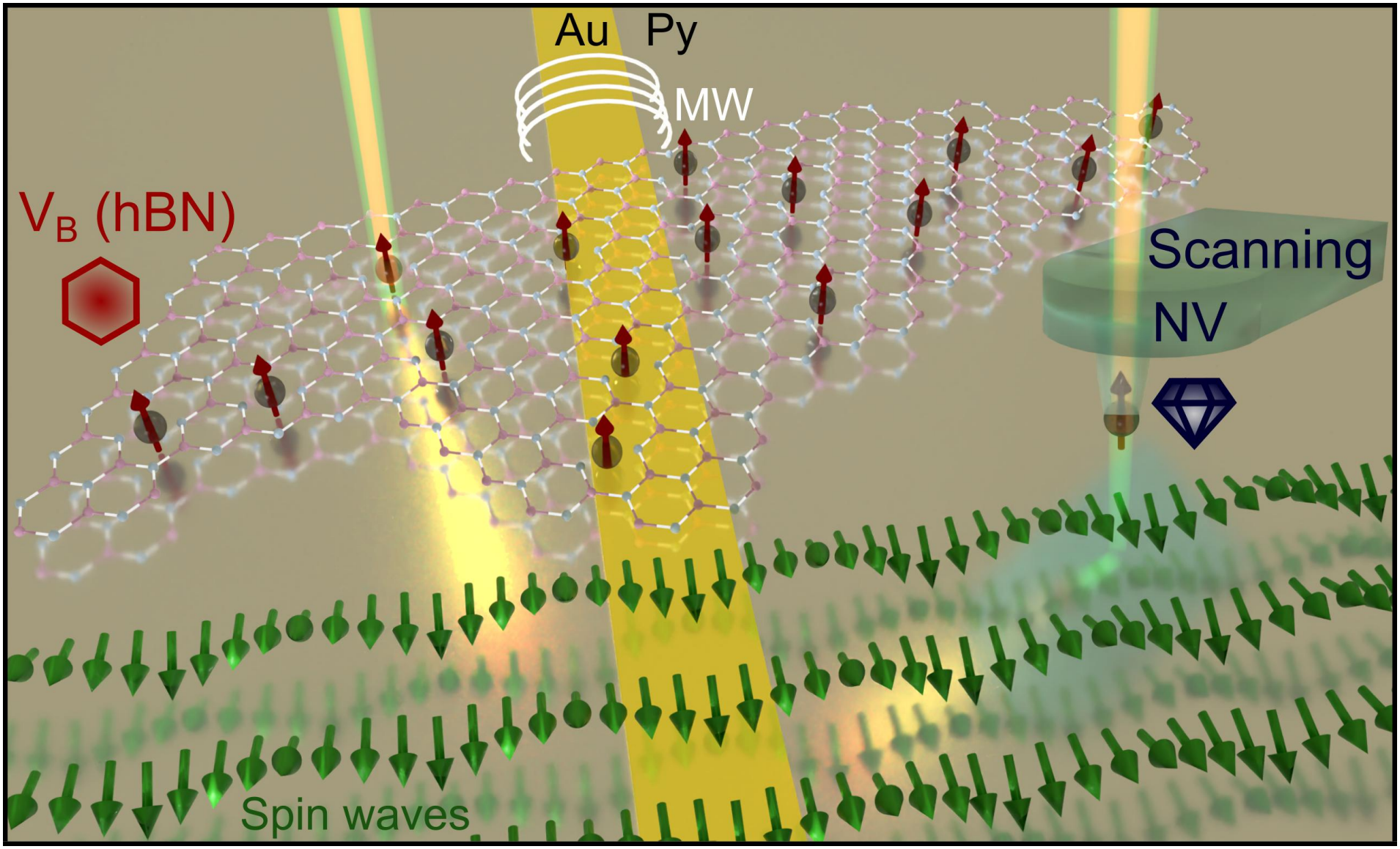
Color center magnetometry for spin-wave imaging



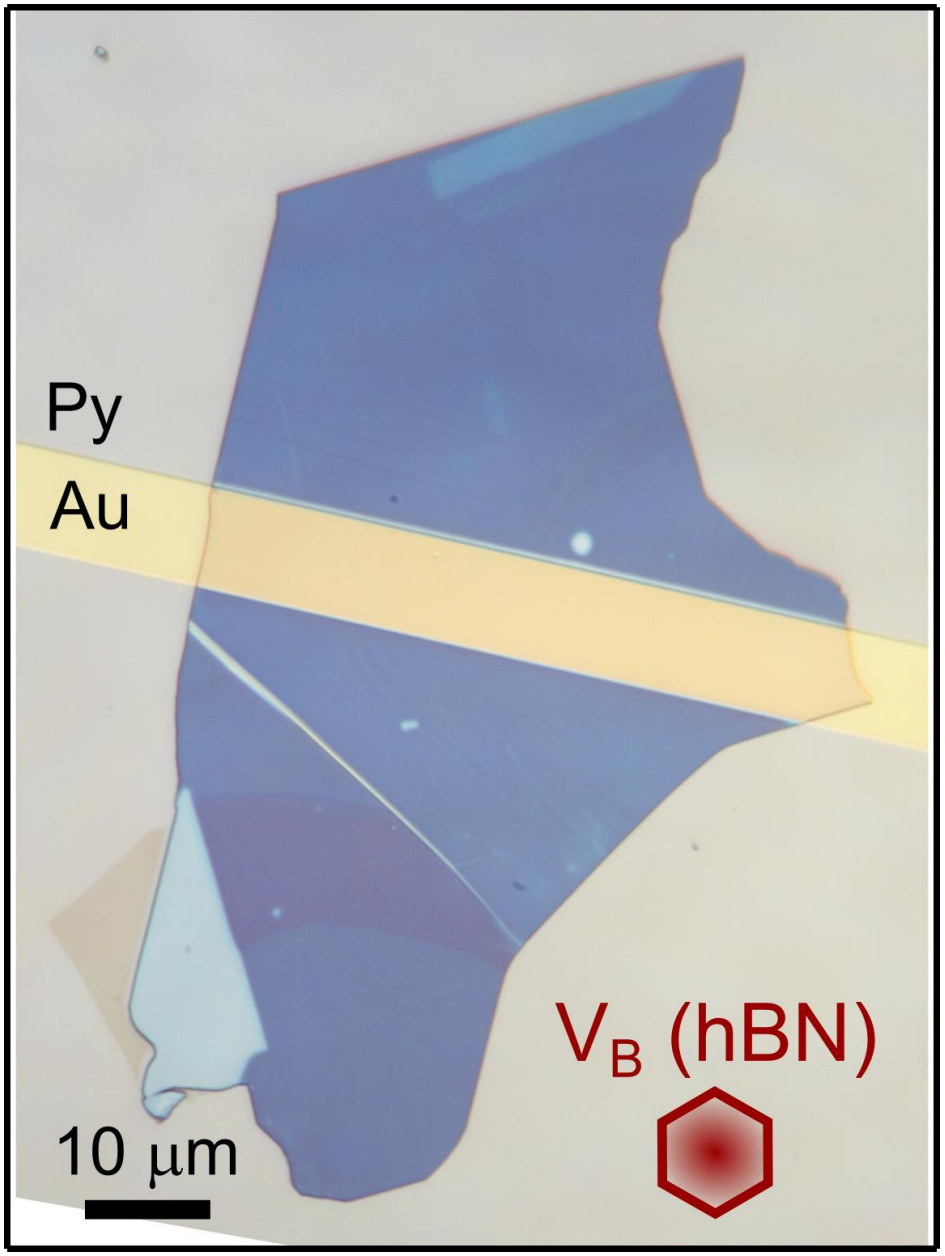
Isofrequency measurements



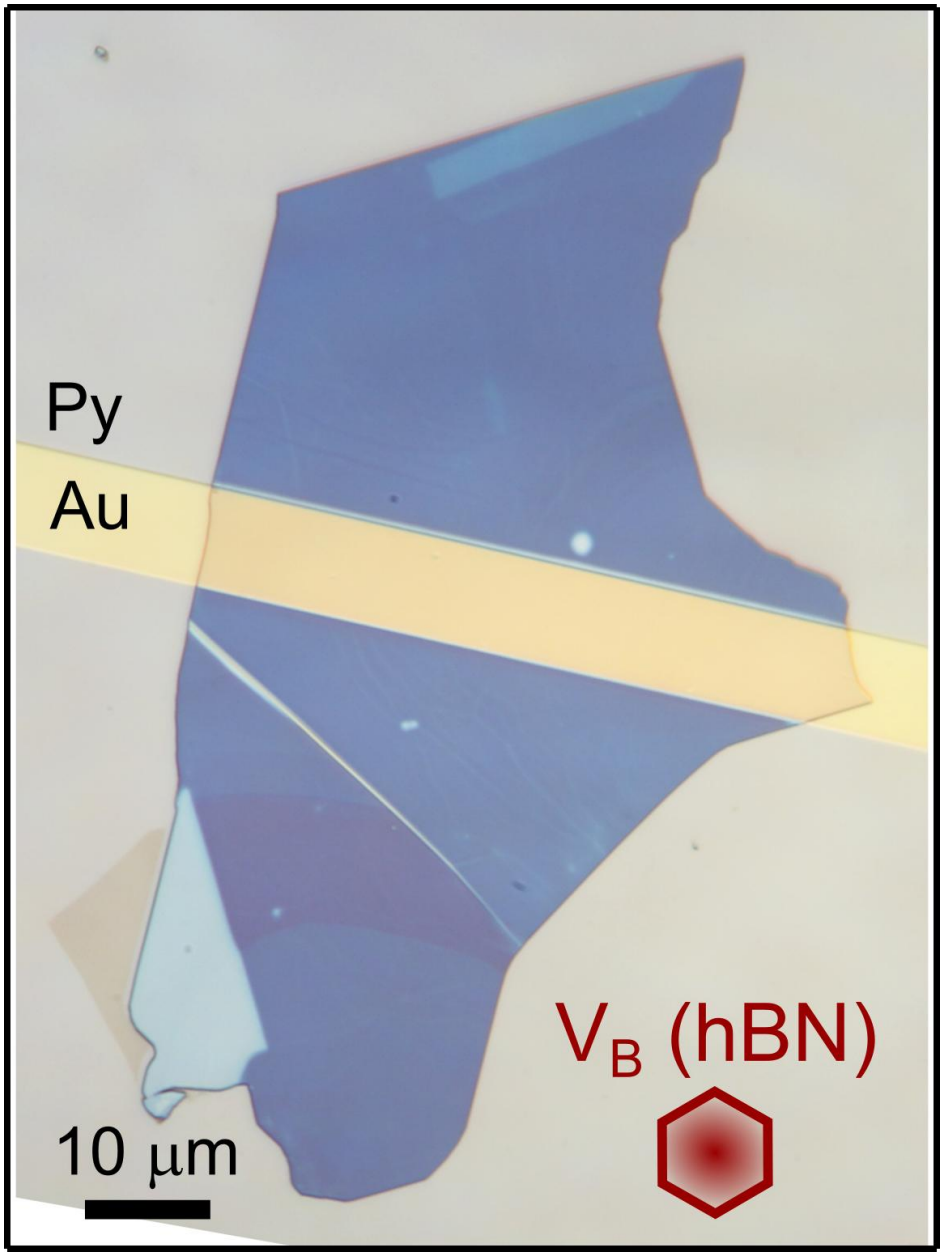
Color center magnetometry for spin-wave imaging

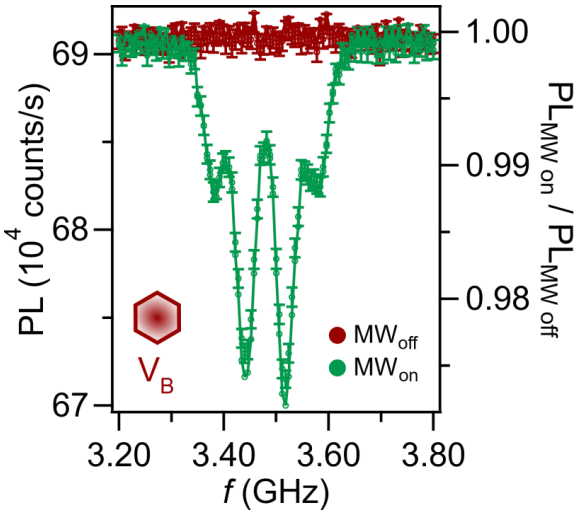


Color center magnetometry for spin-wave imaging

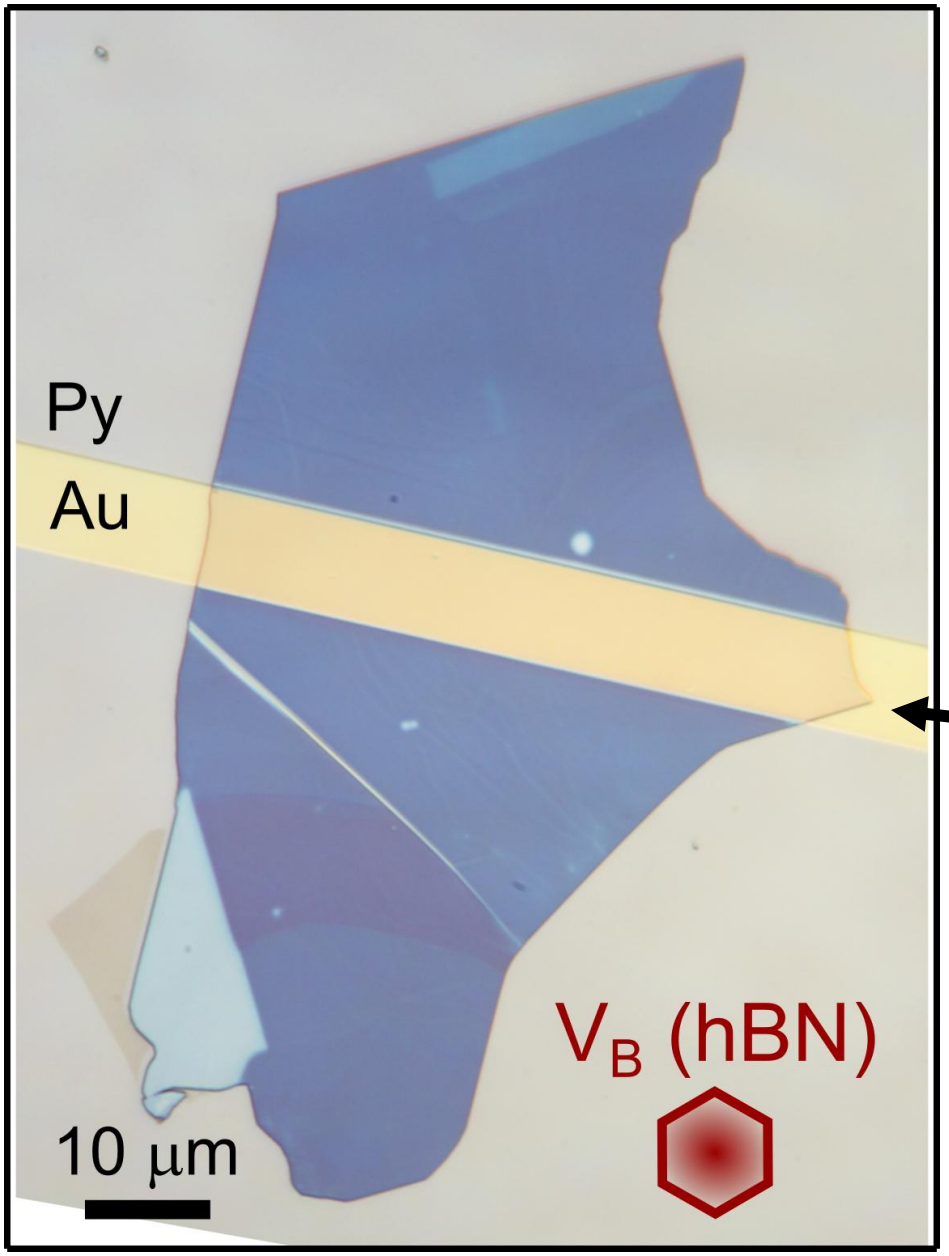


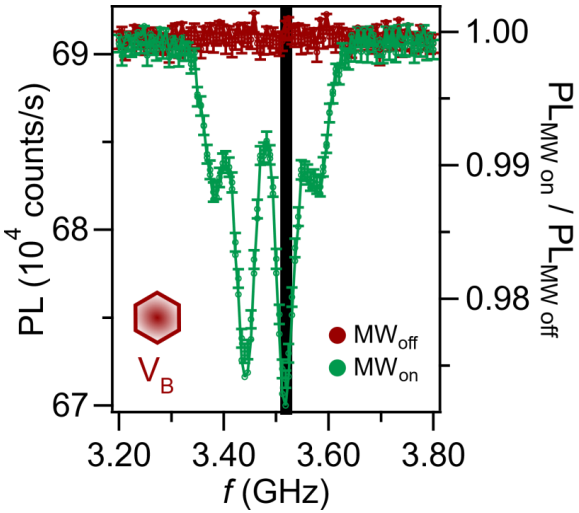
Color center magnetometry for spin-wave imaging



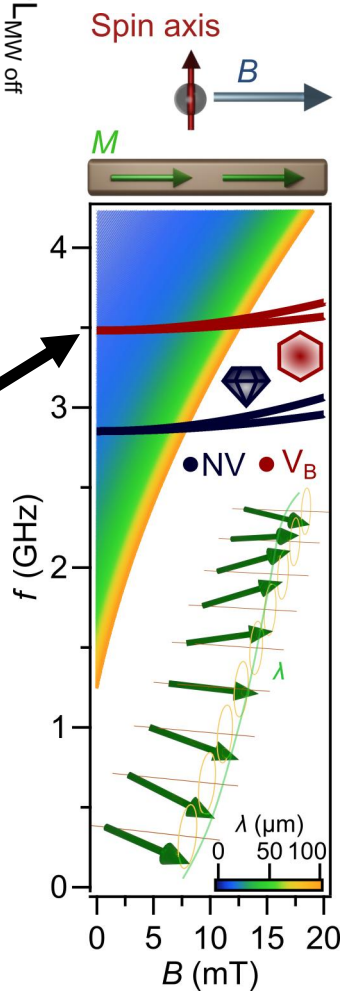


Color center magnetometry for spin-wave imaging

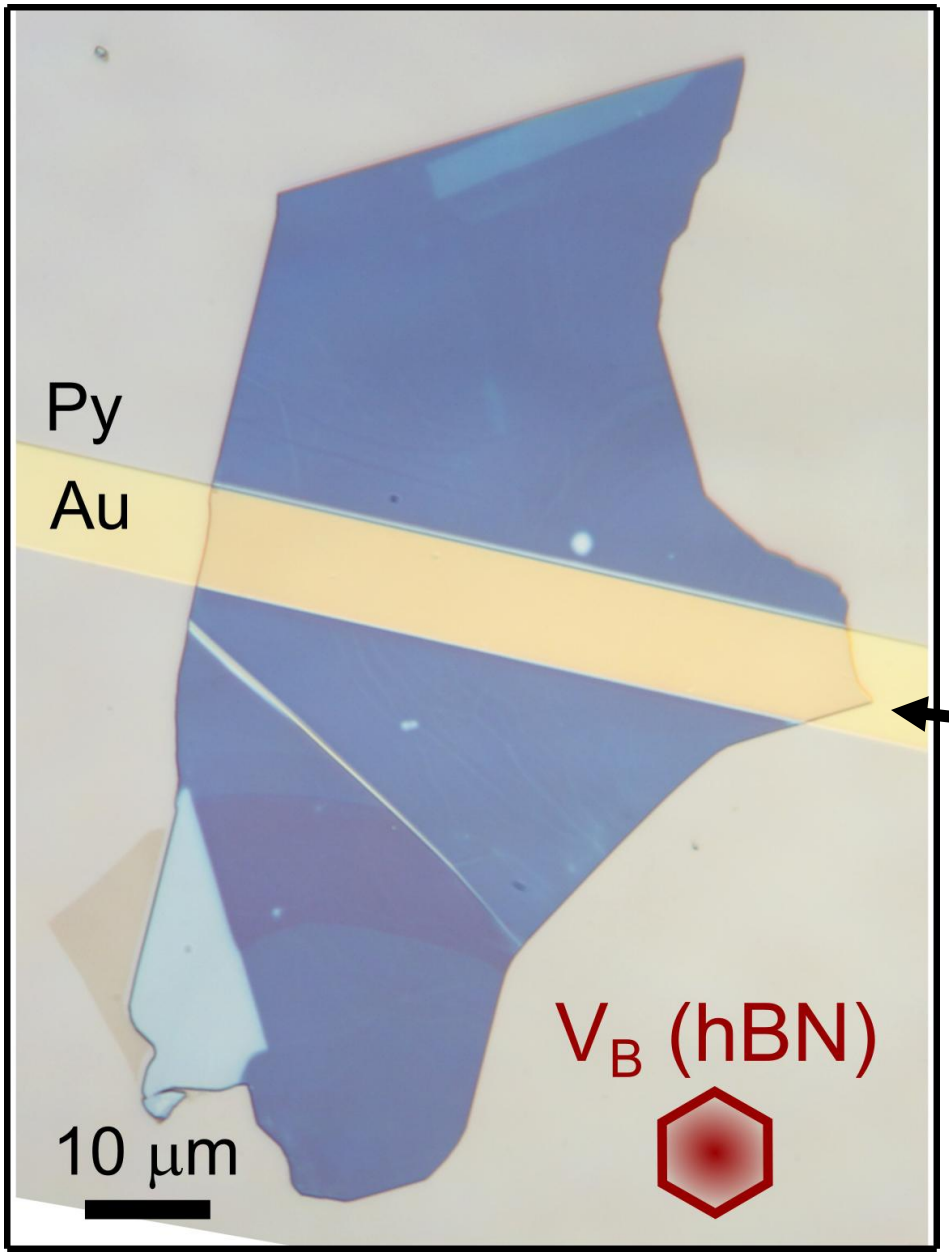


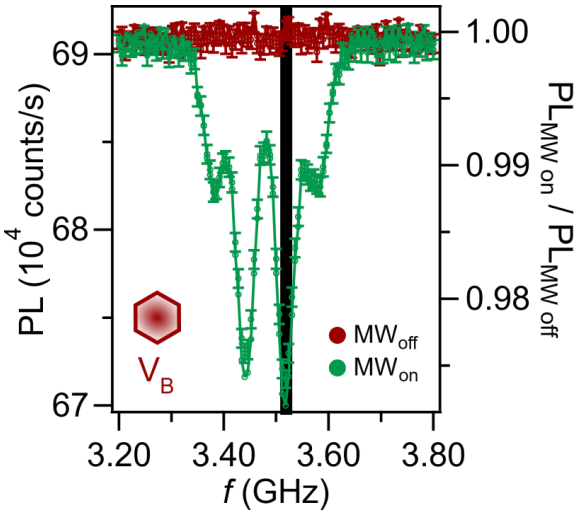


Microwave
***f* = 3.52 GHz**

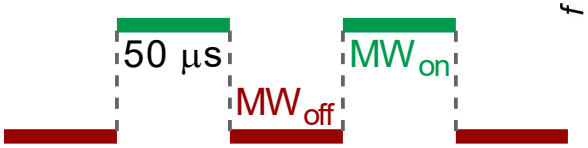


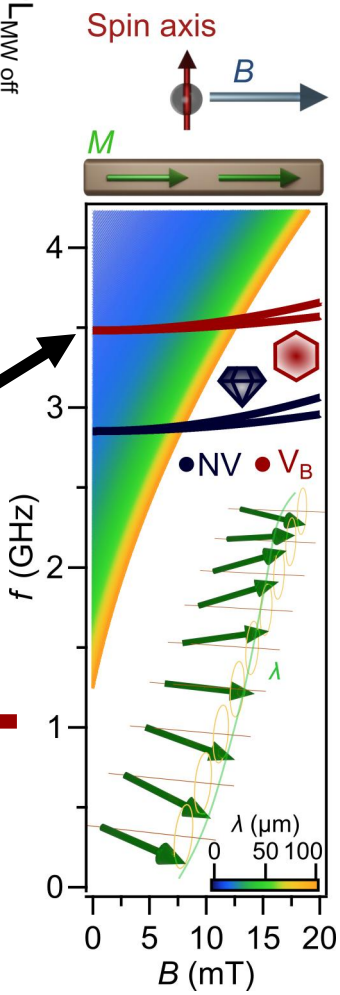
Color center magnetometry for spin-wave imaging



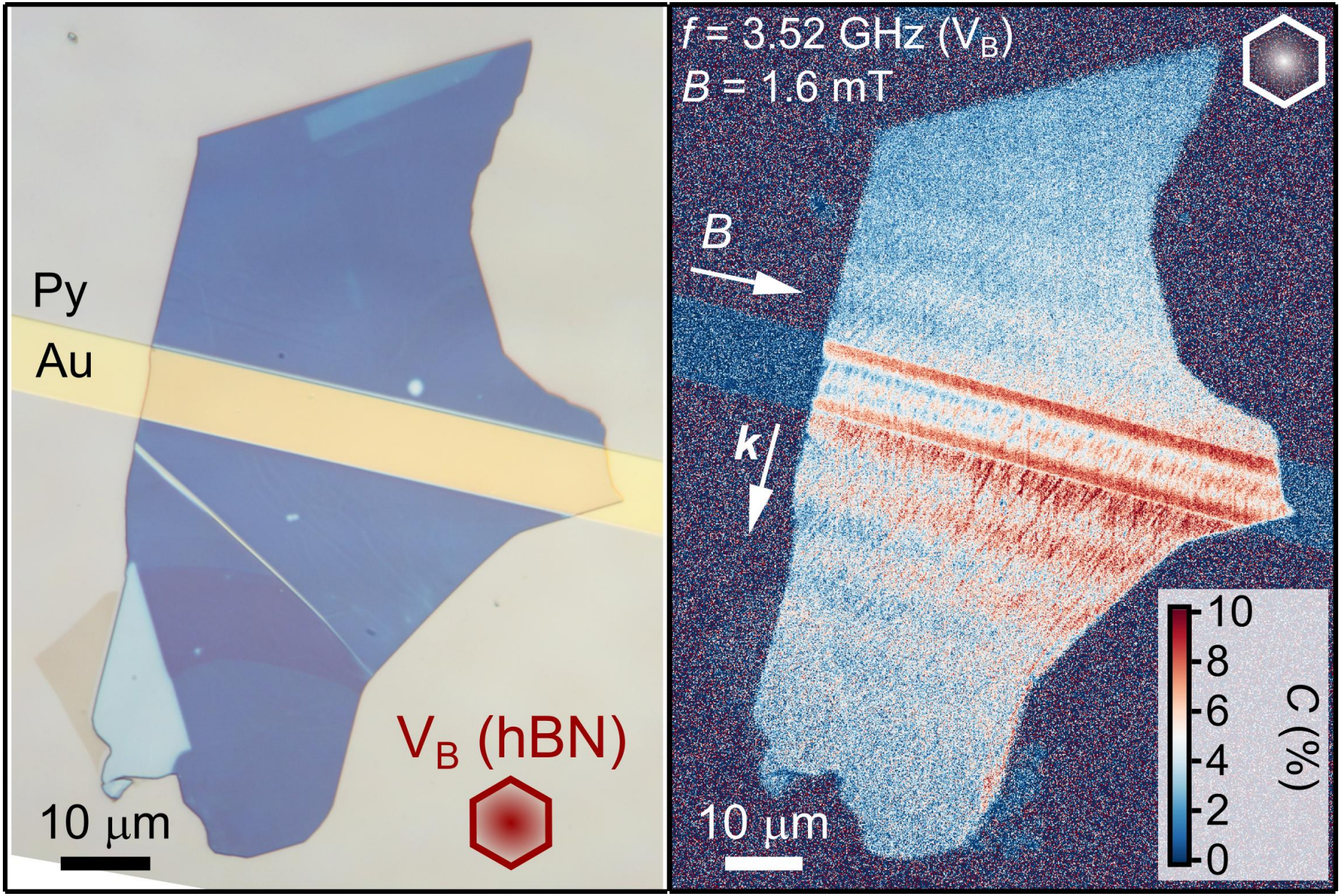


Microwave
***f* = 3.52 GHz**

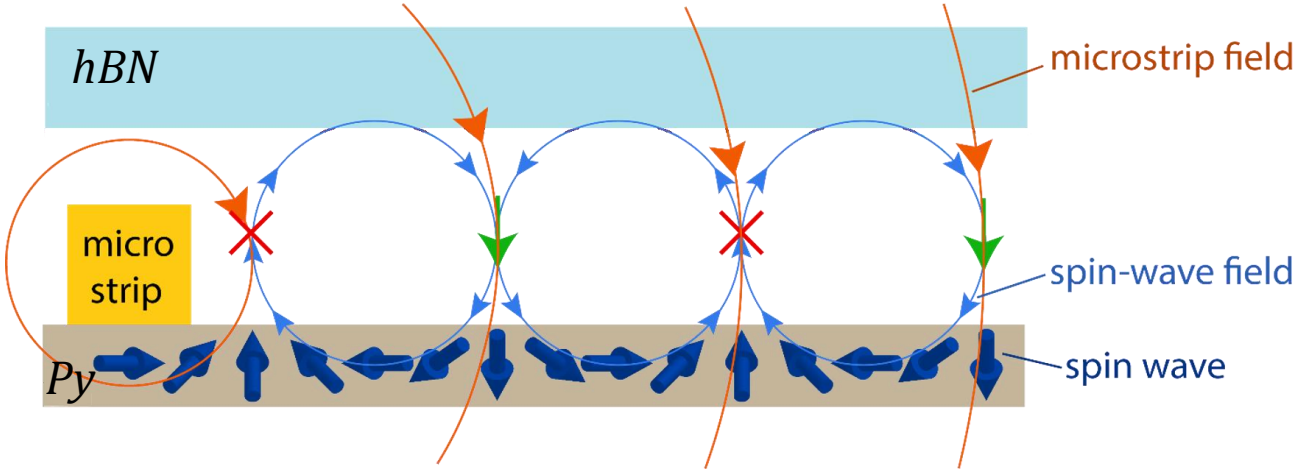


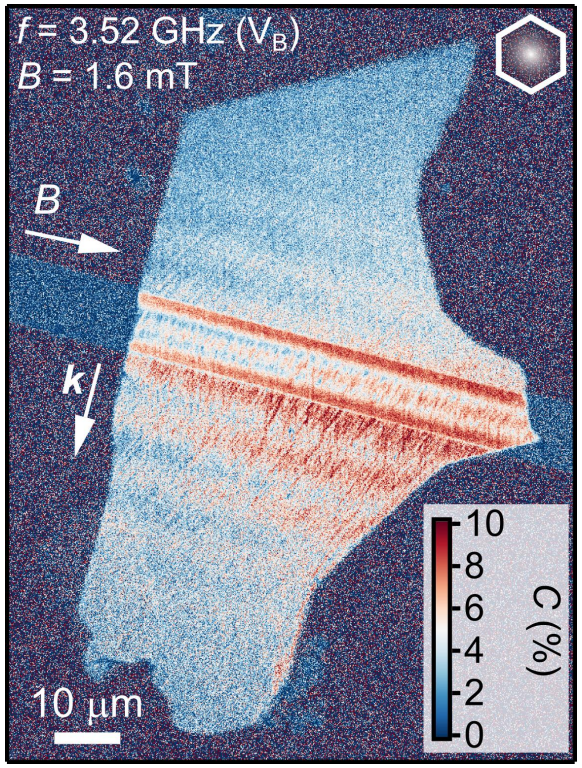


Color center magnetometry for spin-wave imaging

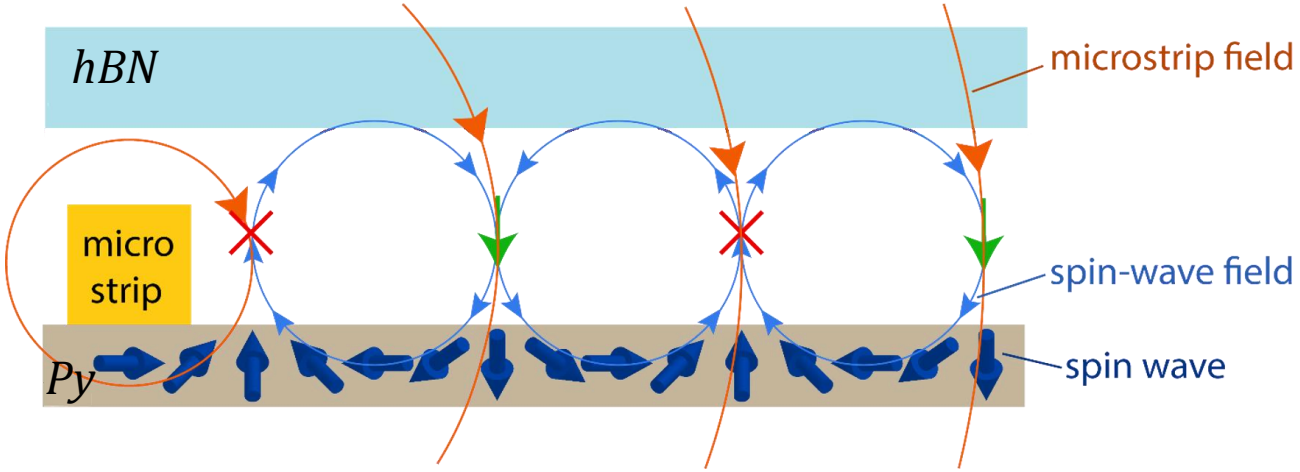


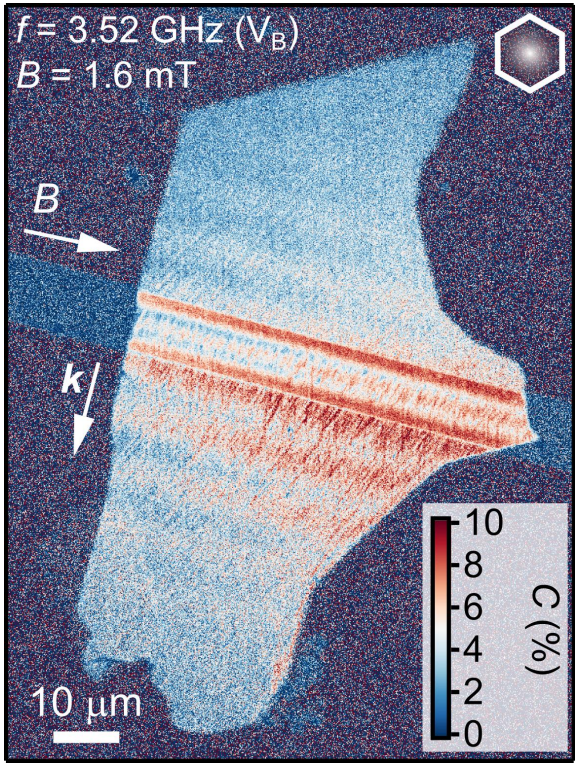
Why we see an interference pattern?

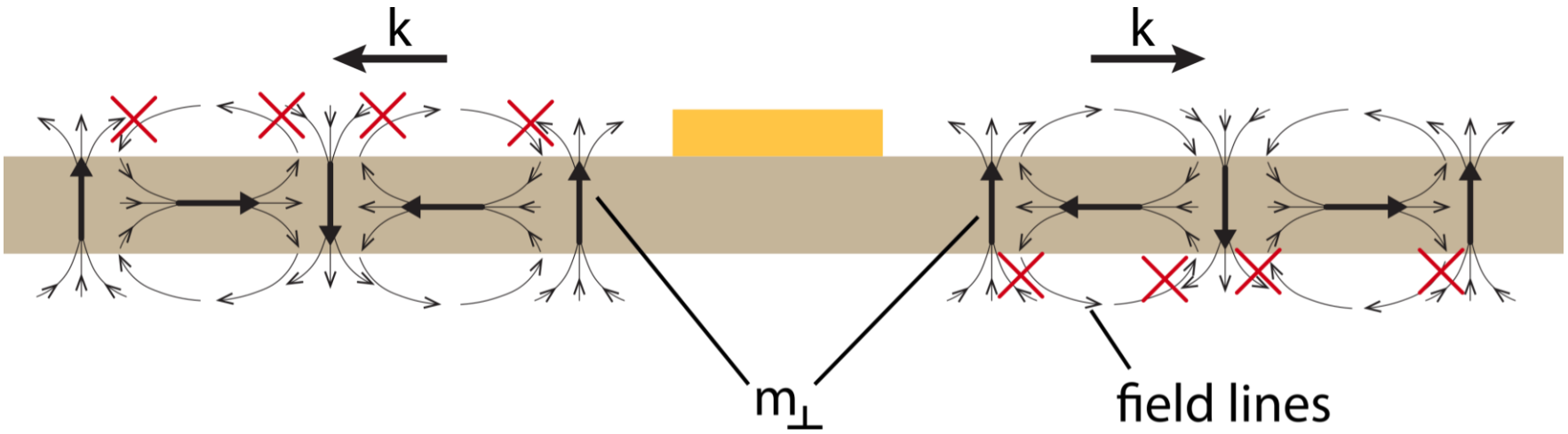




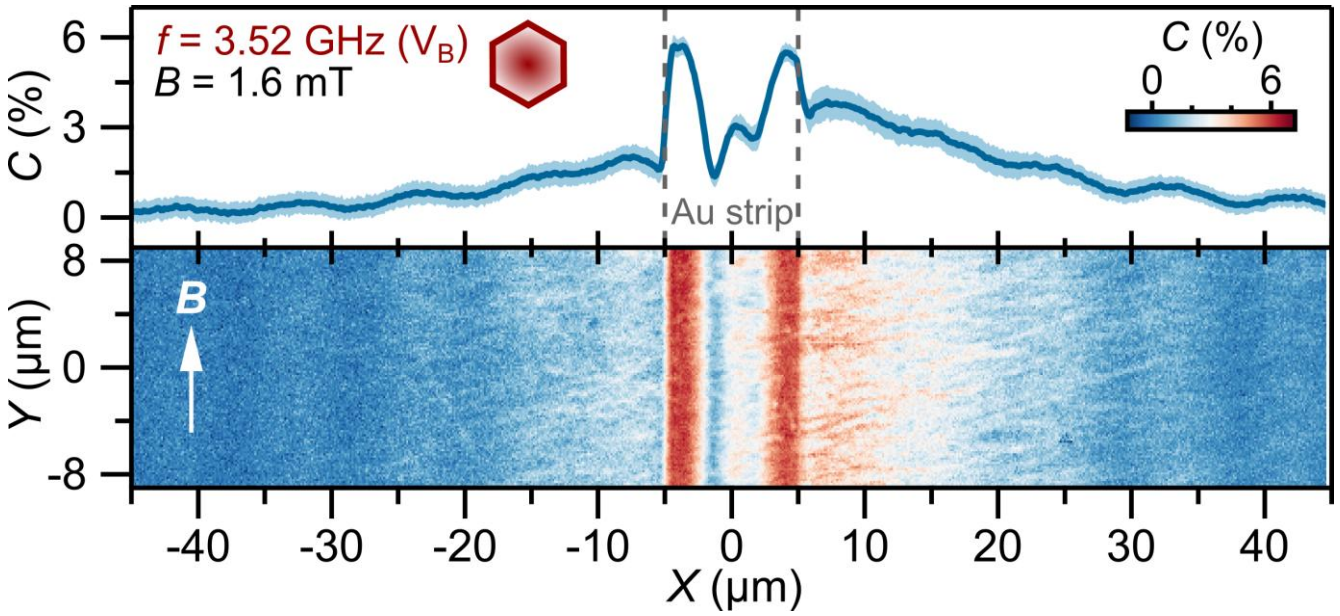
Non-reciprocity

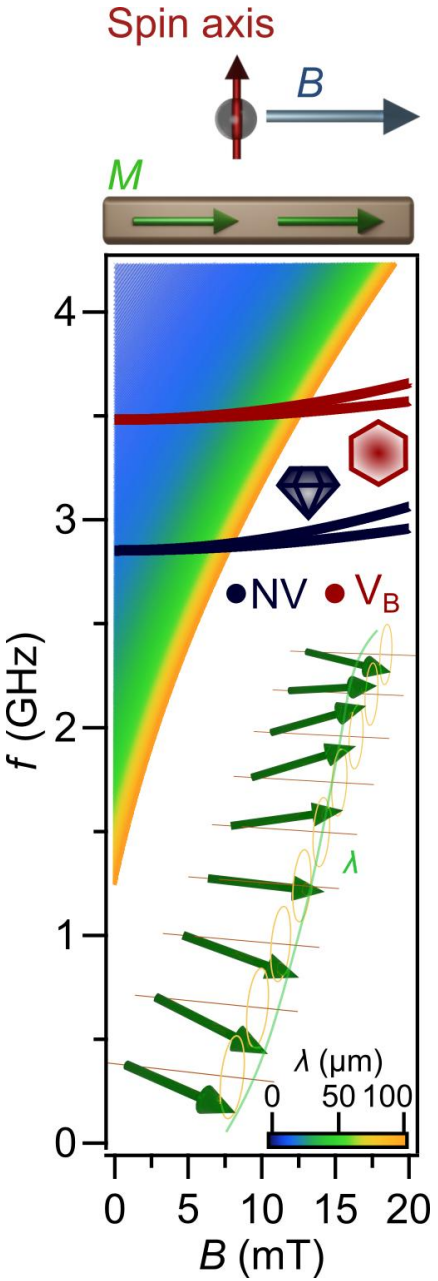




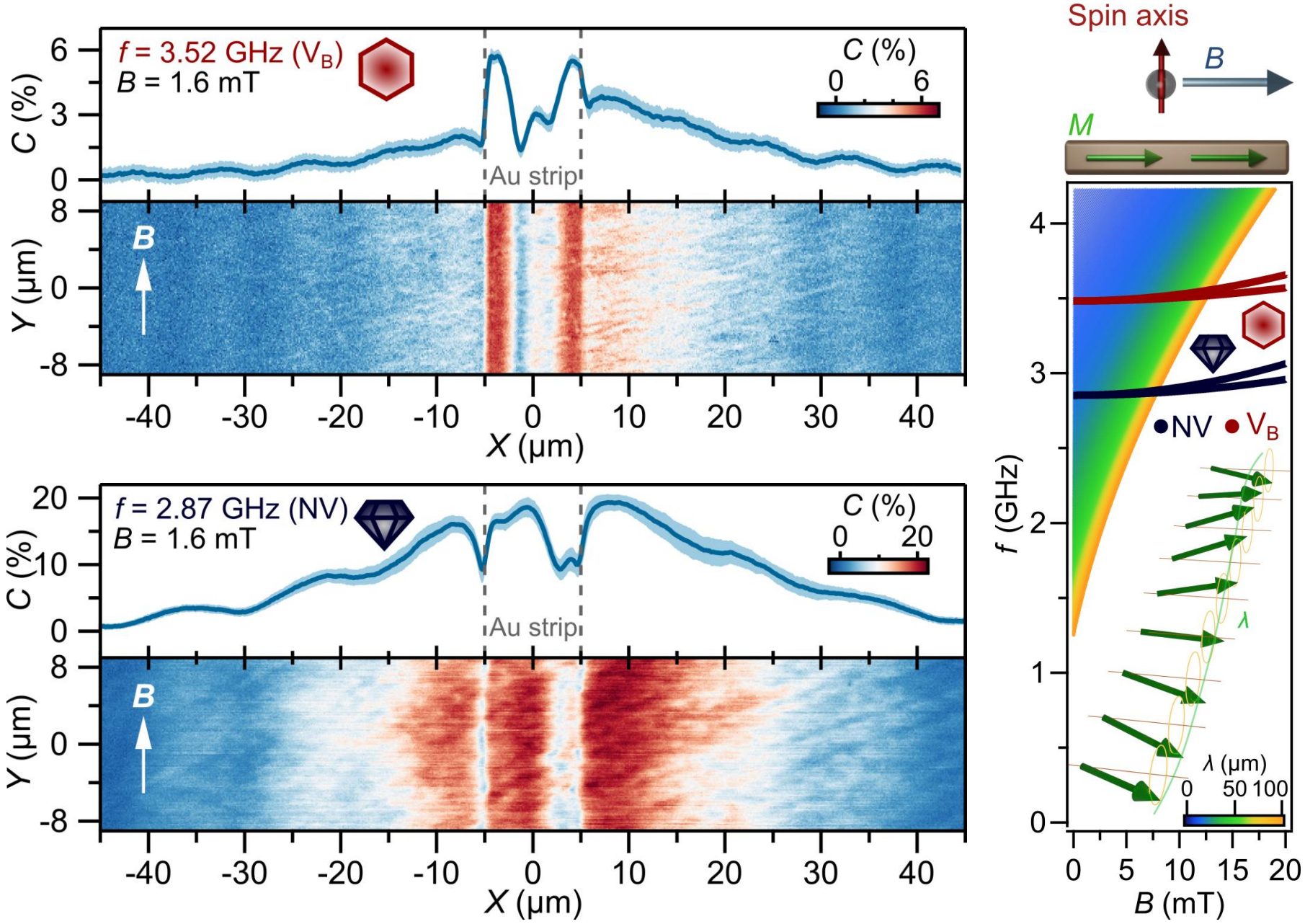


Isofrequency spin-wave imaging

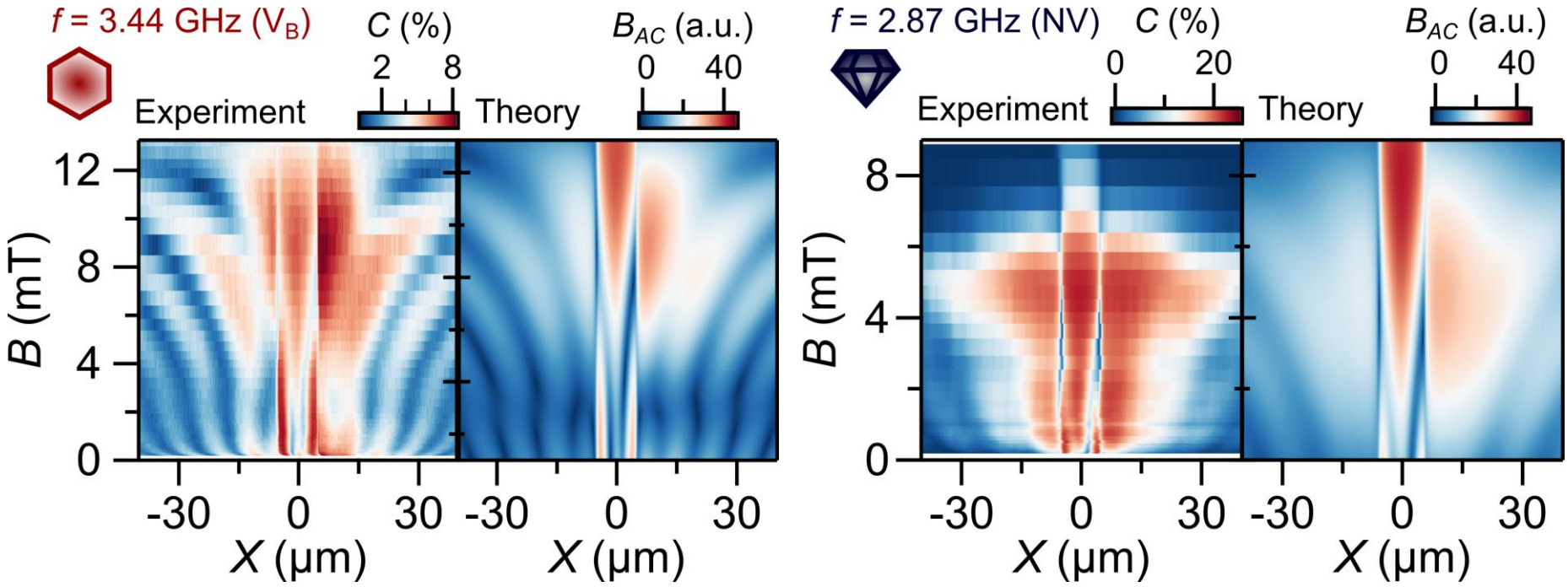




Isofrequency spin-wave imaging

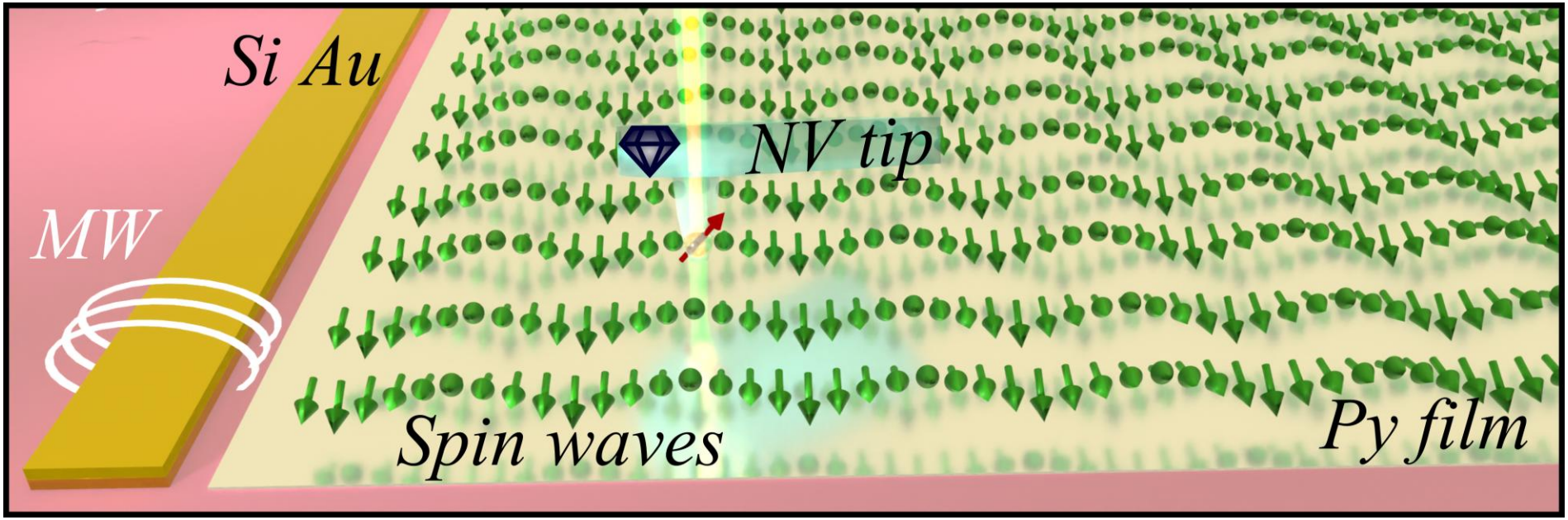


Isofrequency spin-wave imaging

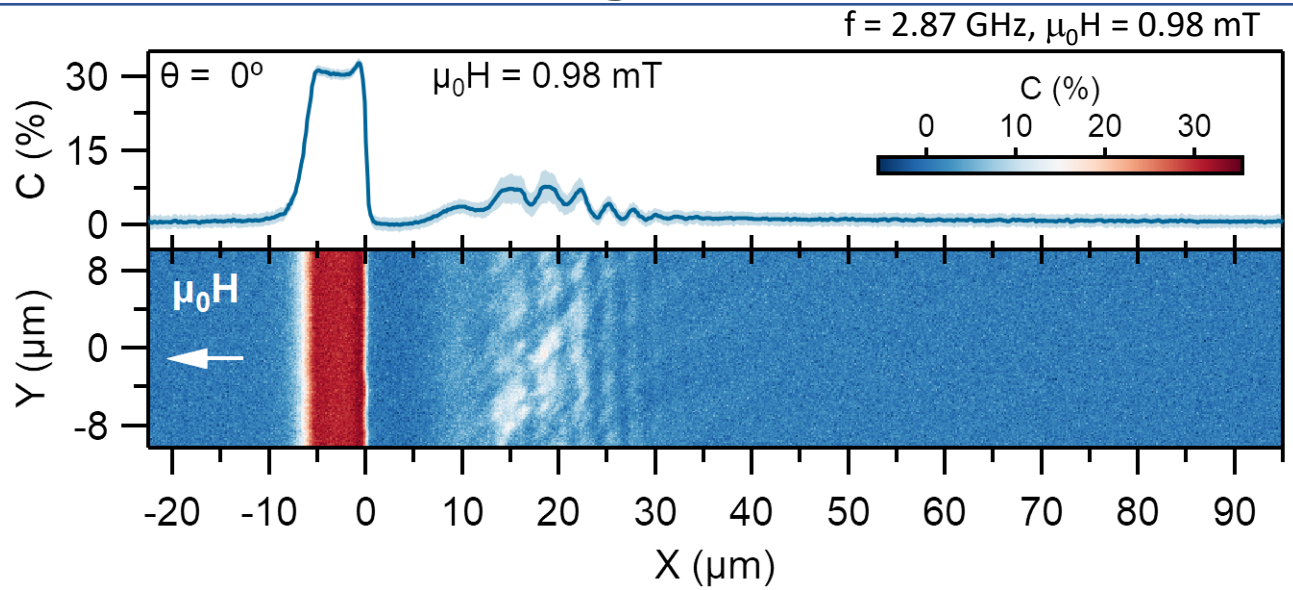


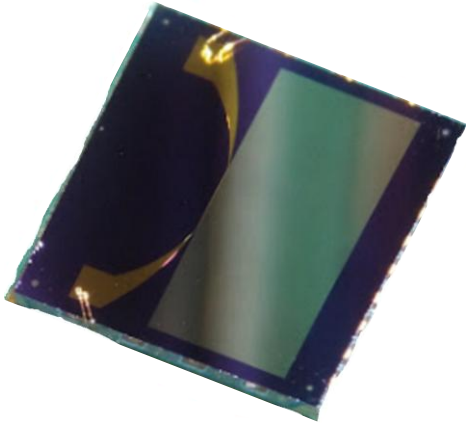
Magnons at the beach

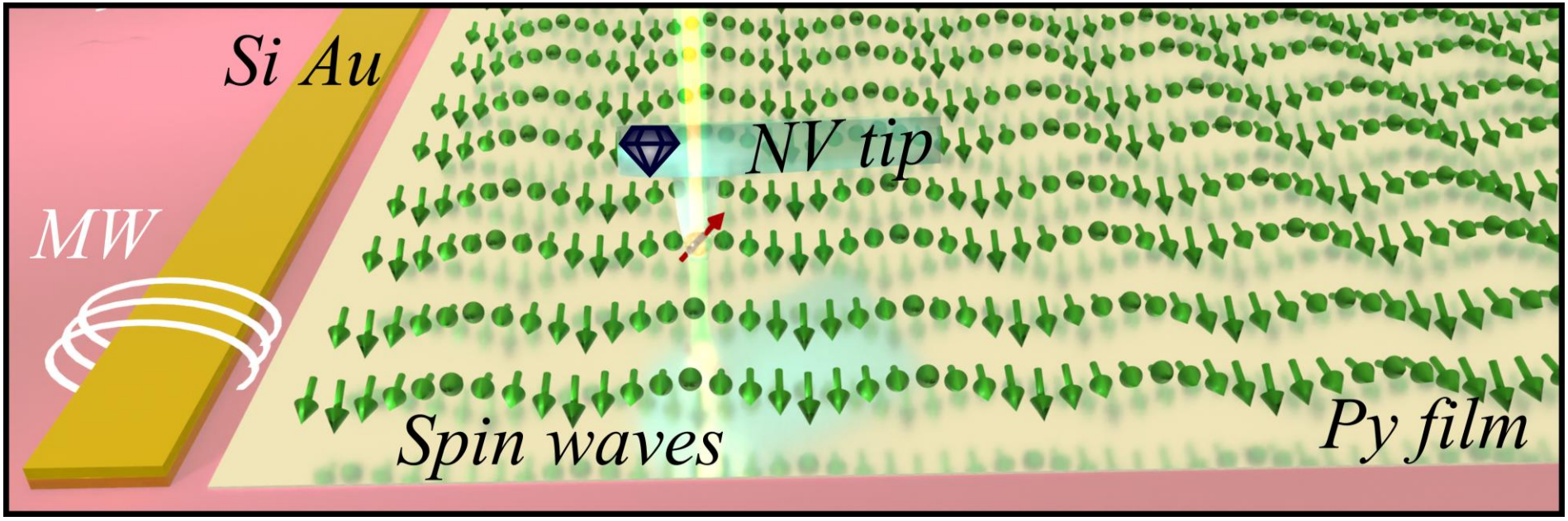




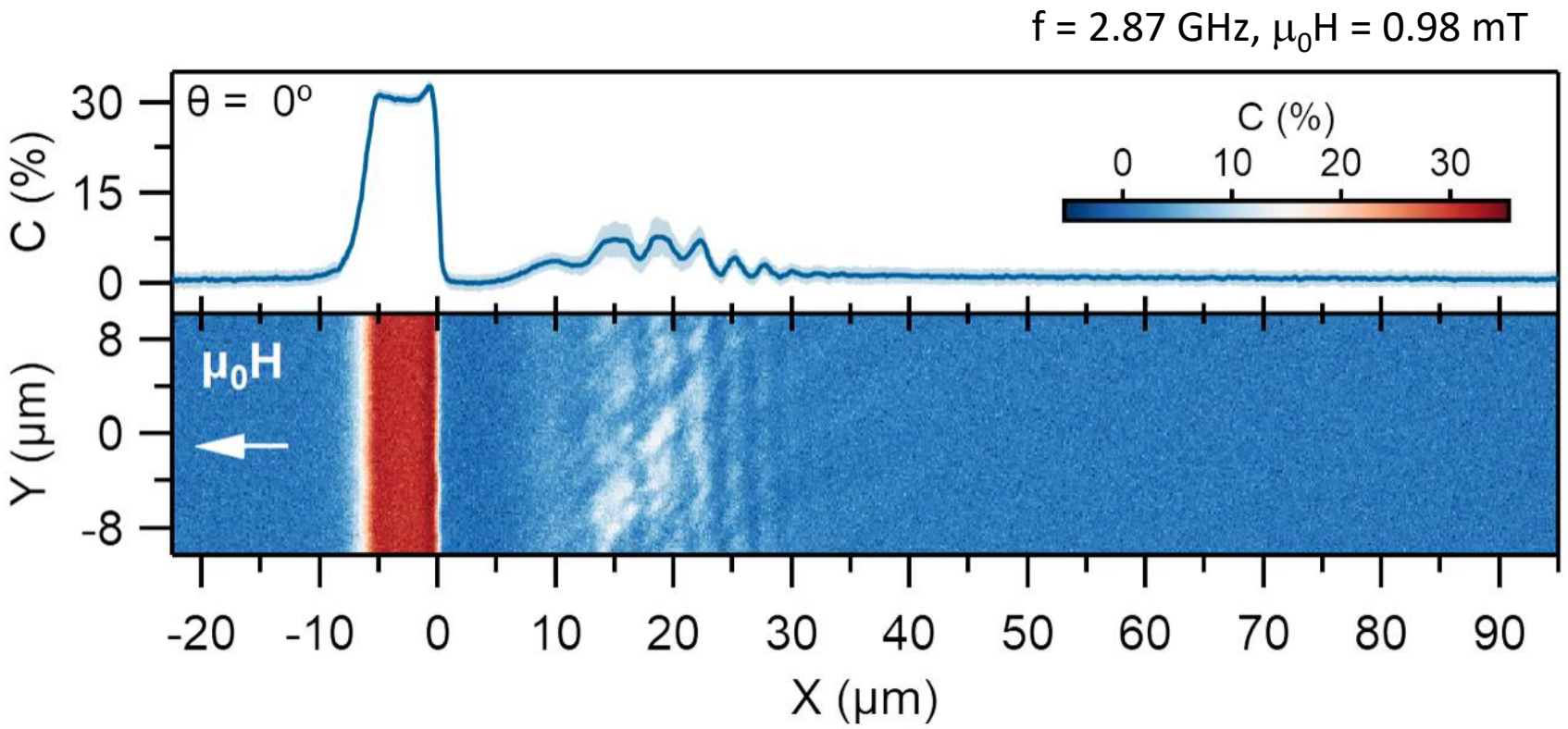
Magnons at the beach





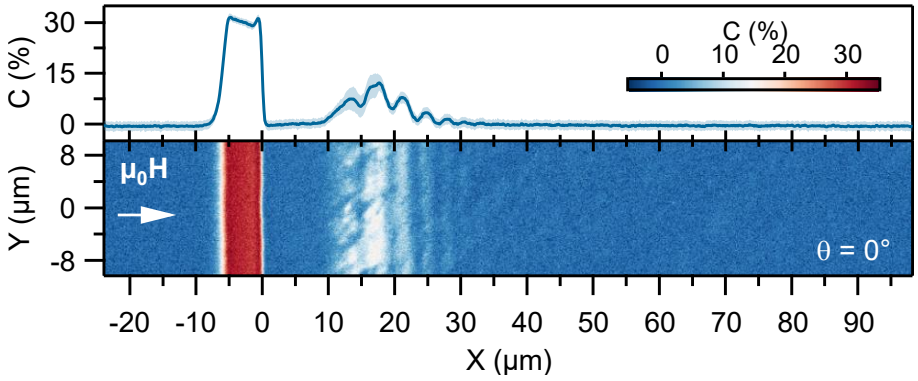


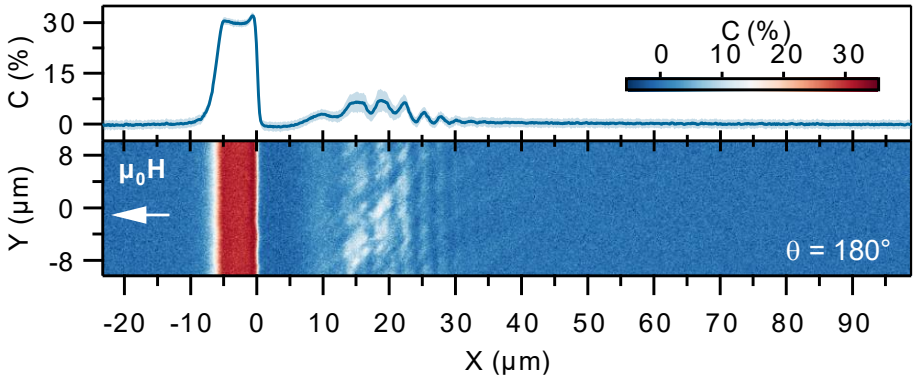
Field-control of spin waves



In-plane field dependence

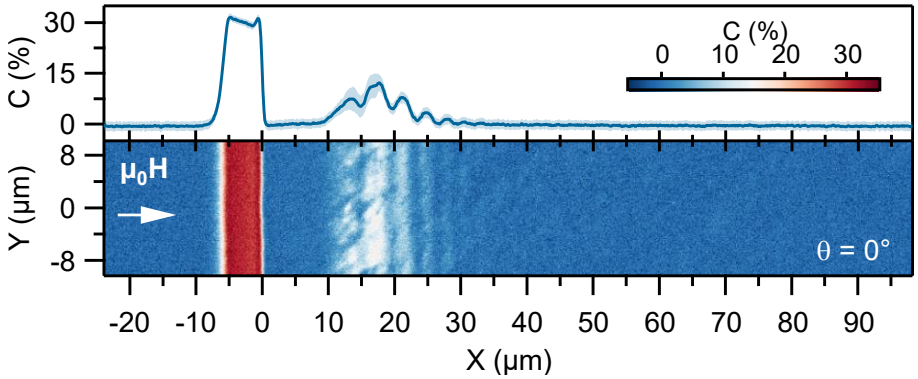
$\mu_0 \vec{H} \parallel \vec{k}$

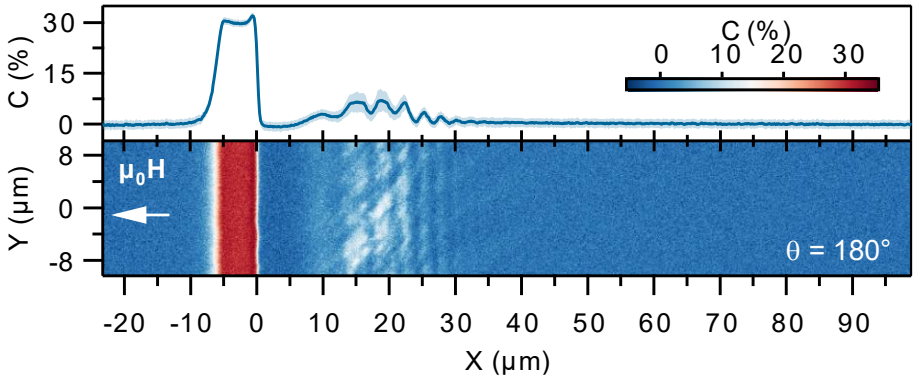




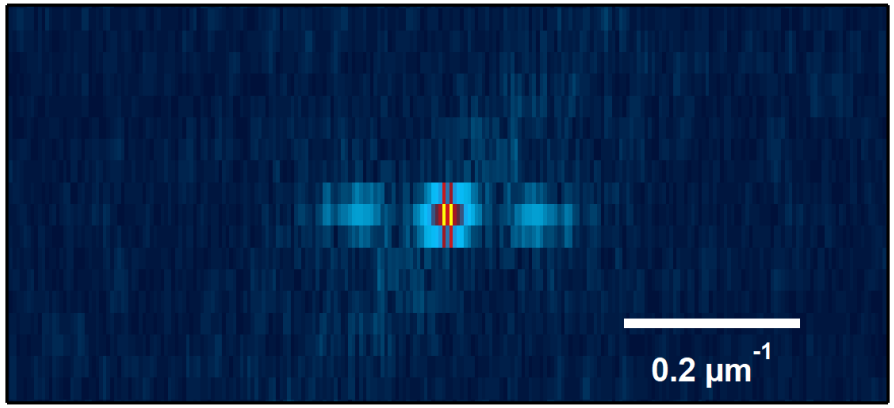
In-plane field dependence

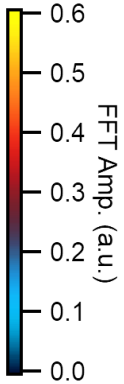
$\mu_0 \vec{H} \parallel \vec{k}$

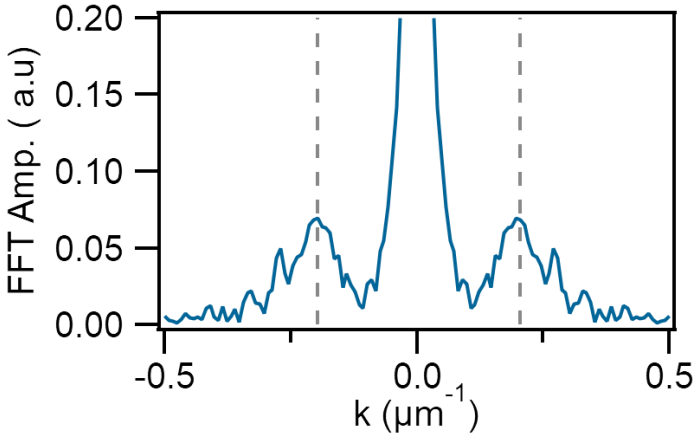




λ ~ 3.4 μm

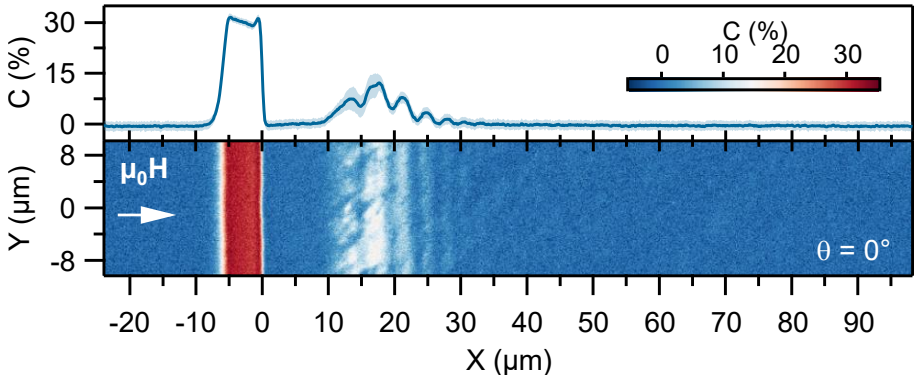


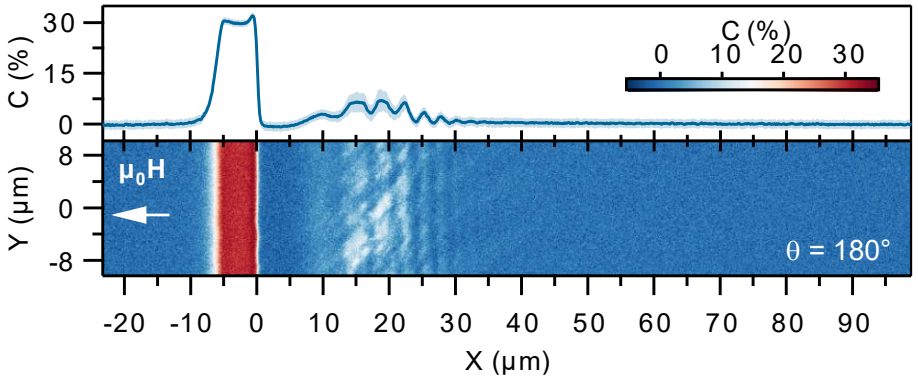




In-plane field dependence

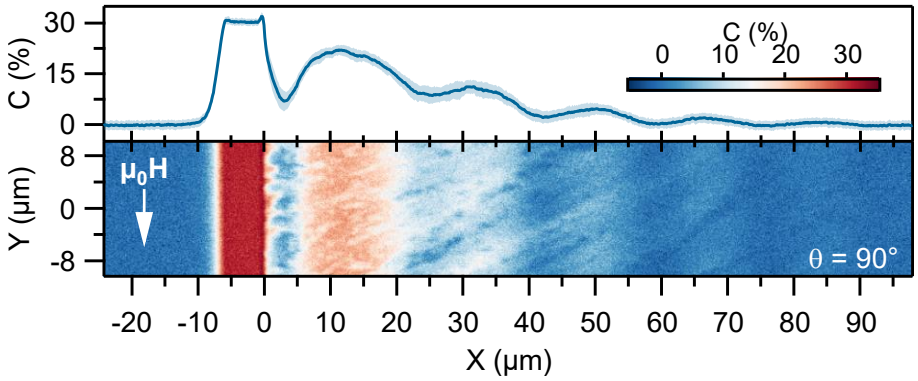
$\mu_0 \vec{H} \parallel \vec{k}$

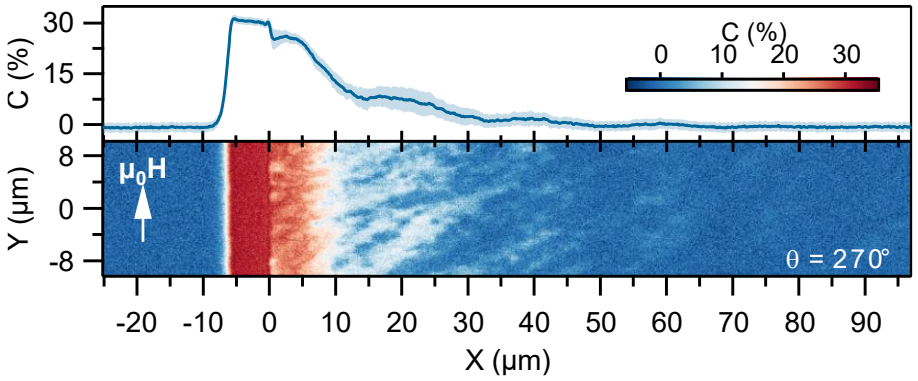




$\lambda \sim 3.4$ μm

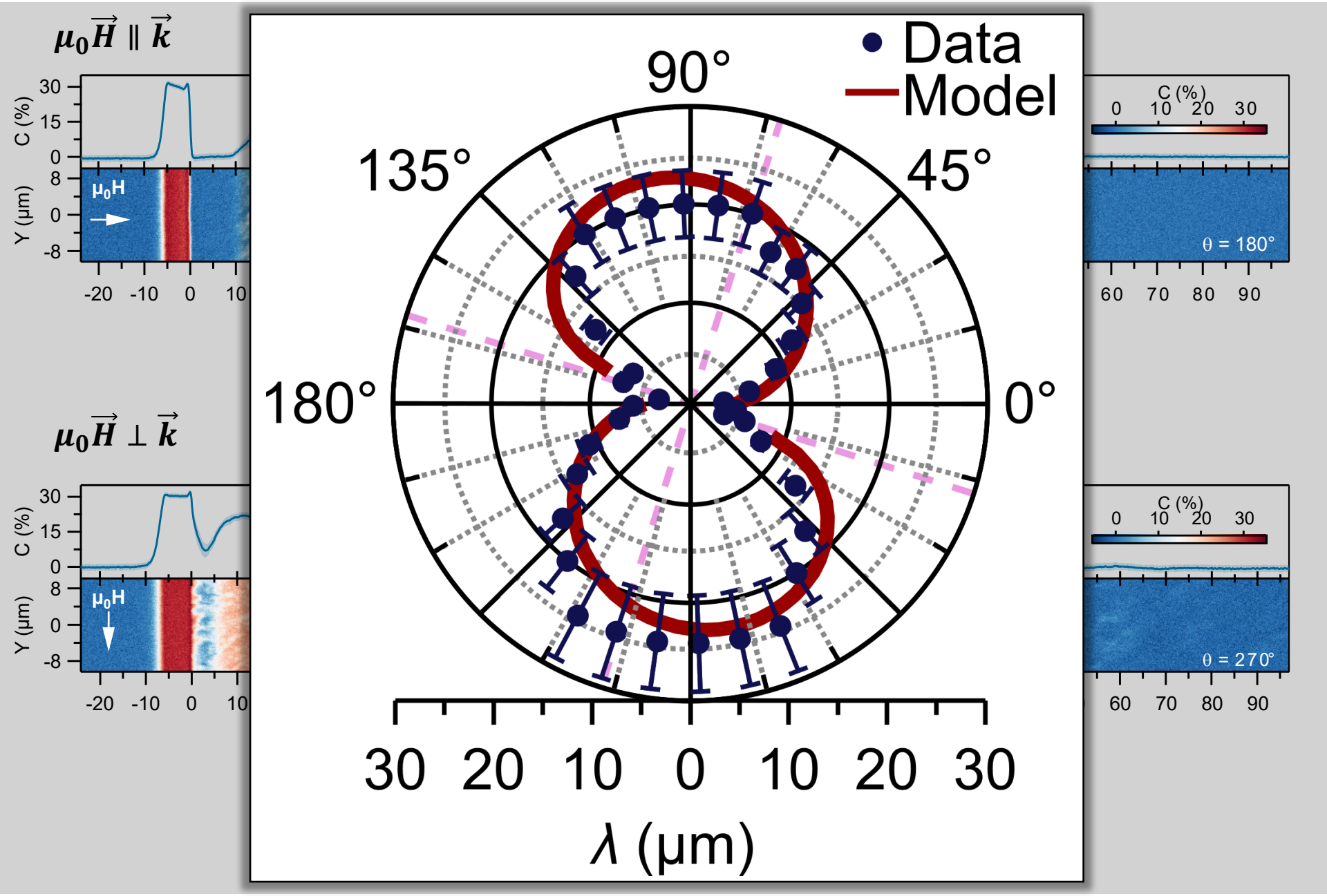
$\mu_0 \vec{H} \perp \vec{k}$





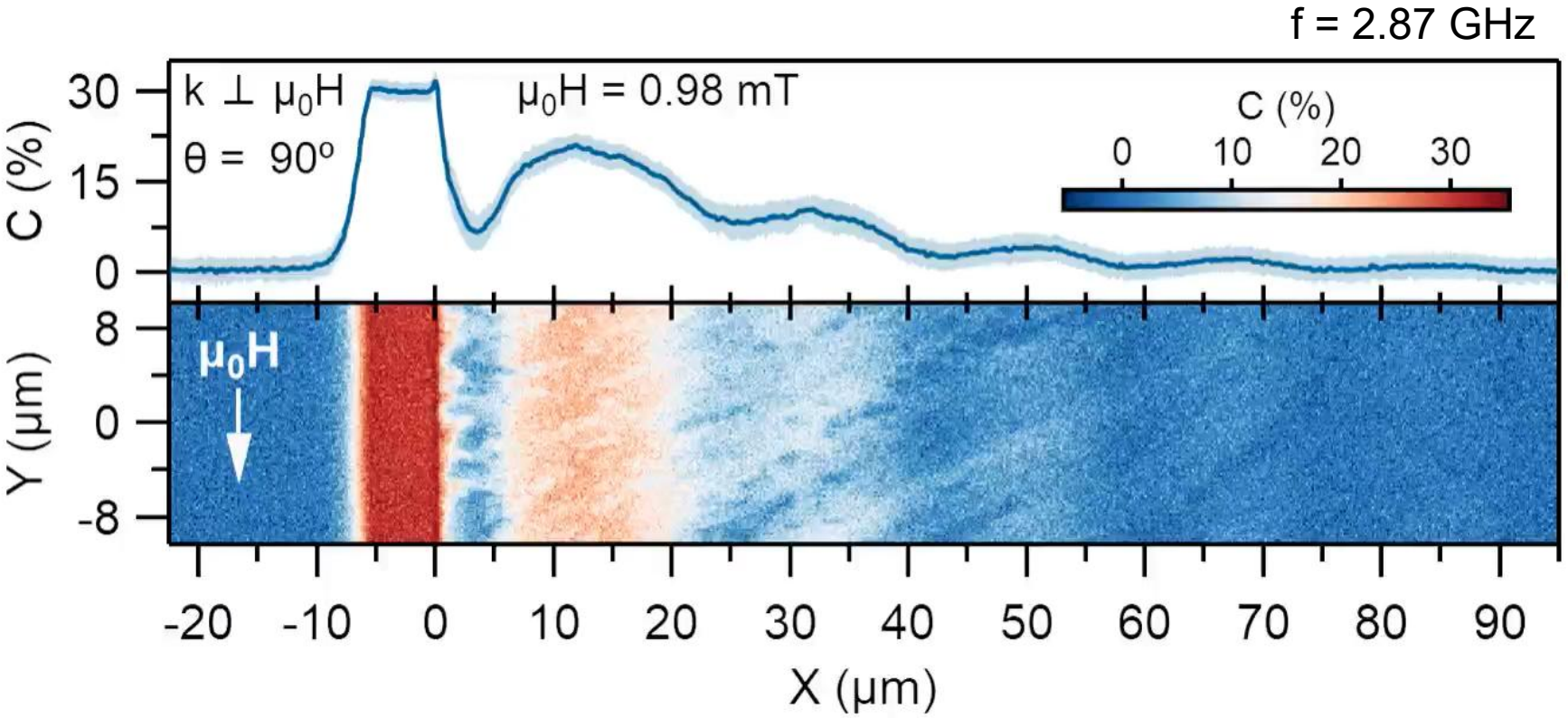
$\lambda \sim 20$ μm

In-plane field dependence



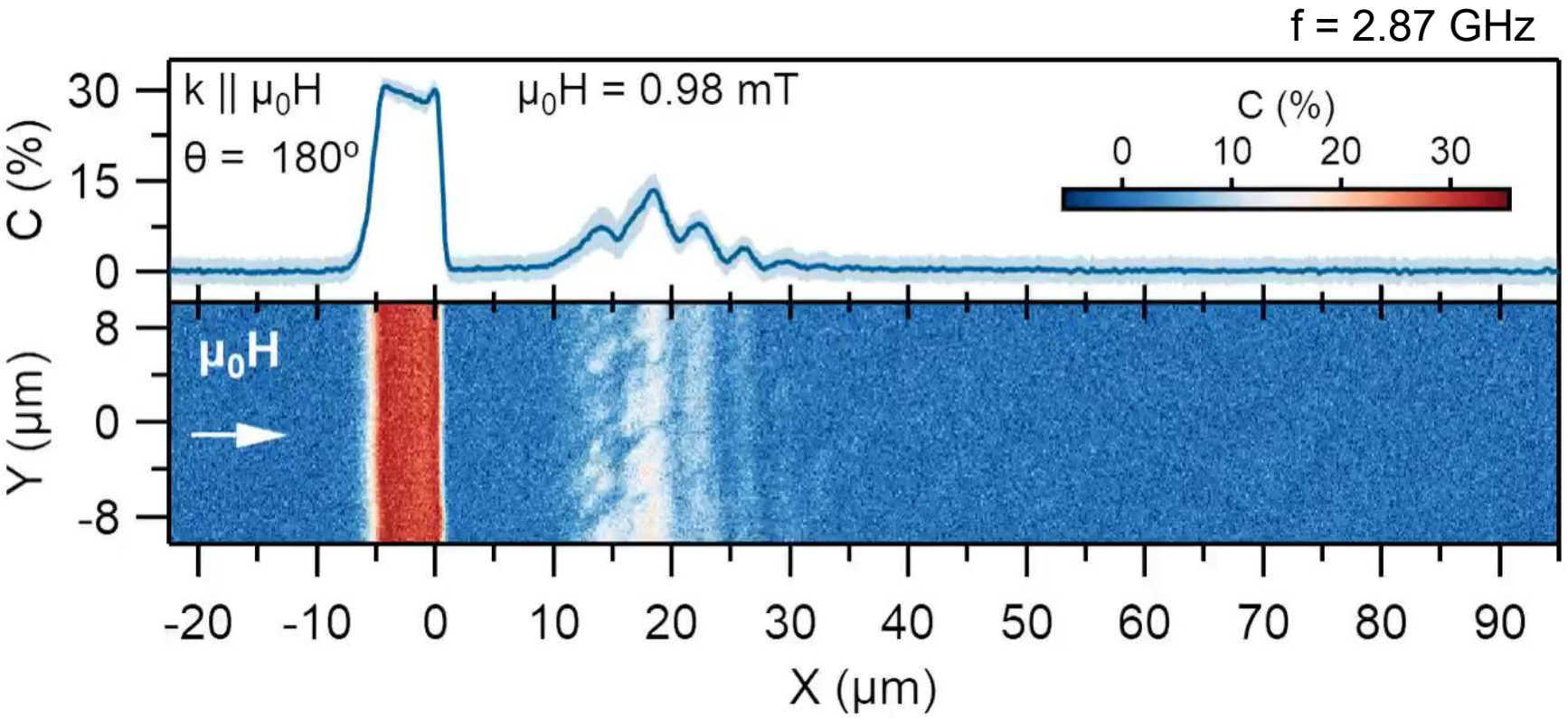
Field strength dependence

$\mu_0\vec{H} \perp \vec{k}$

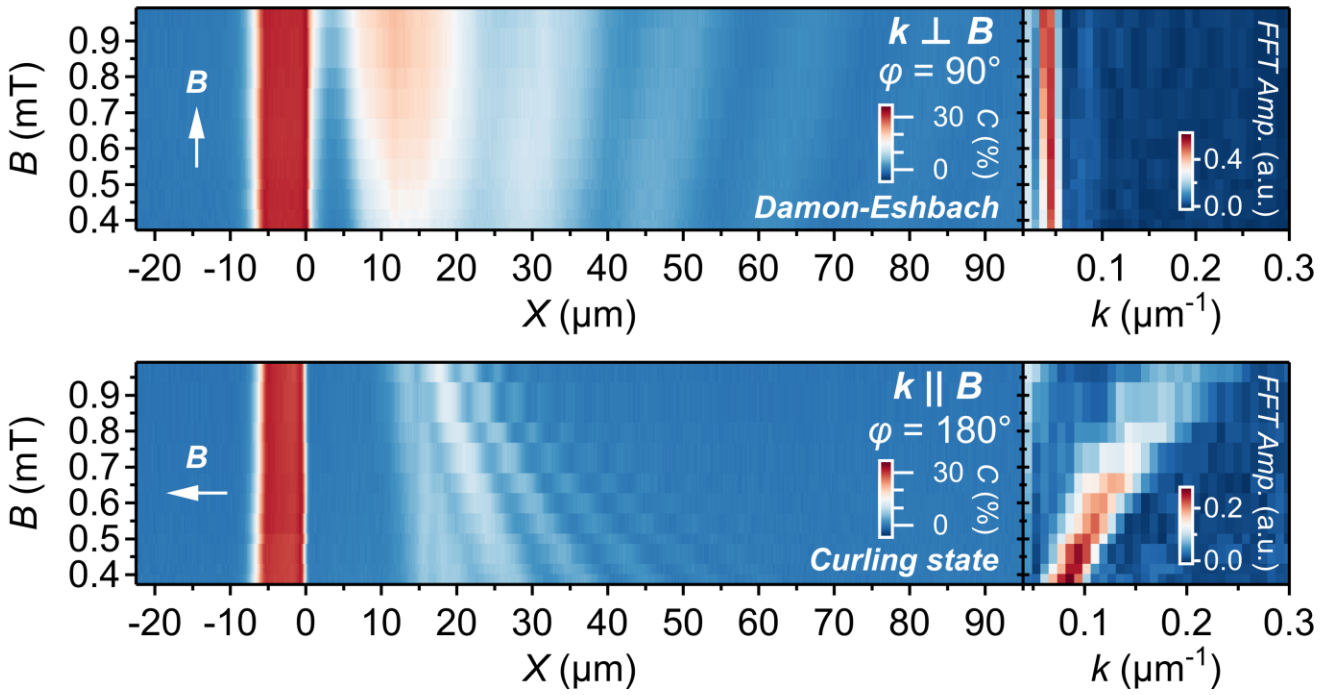


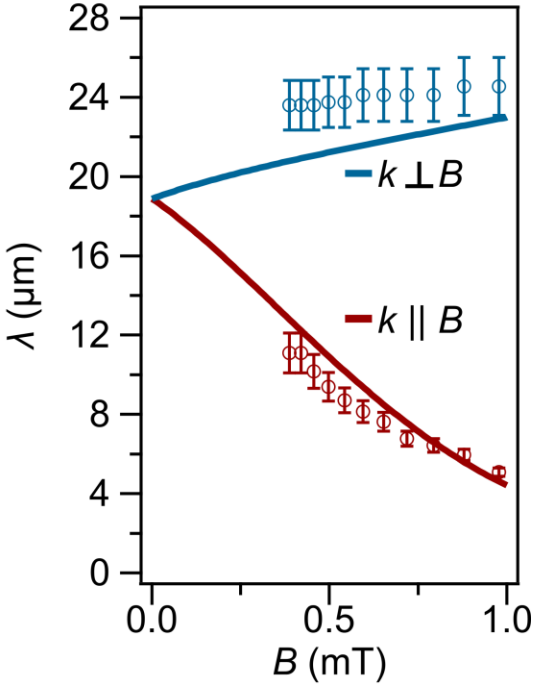
Field strength dependence

$\mu_0\vec{H} \parallel \vec{k}$

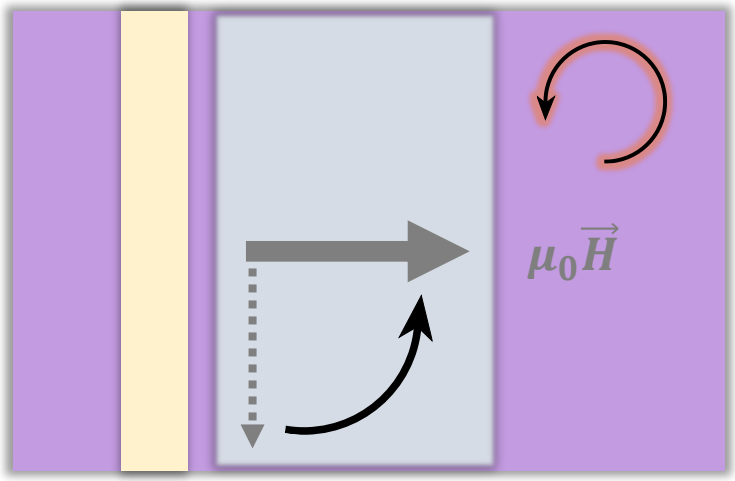


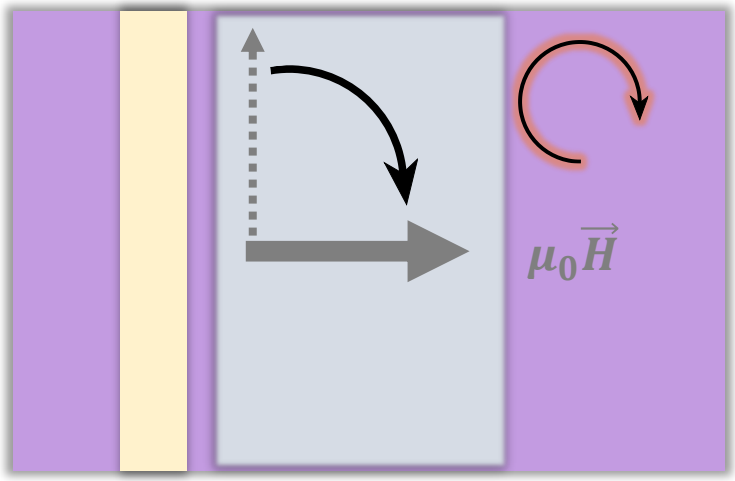
Field strength dependence



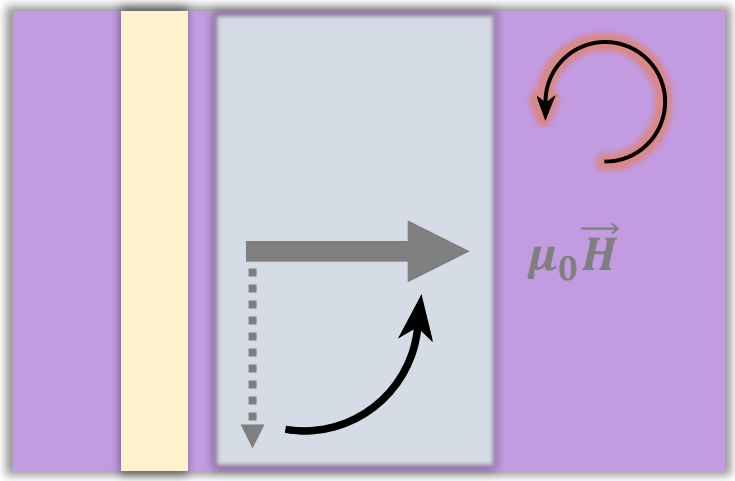


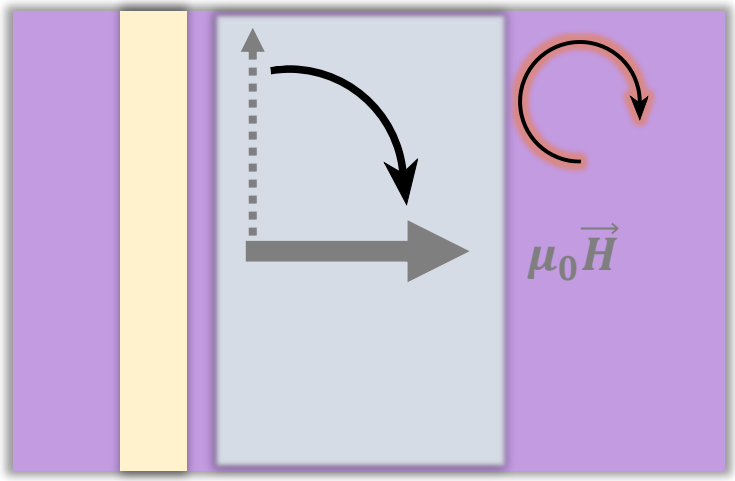
Bistability at the edge: field-control of spin textures

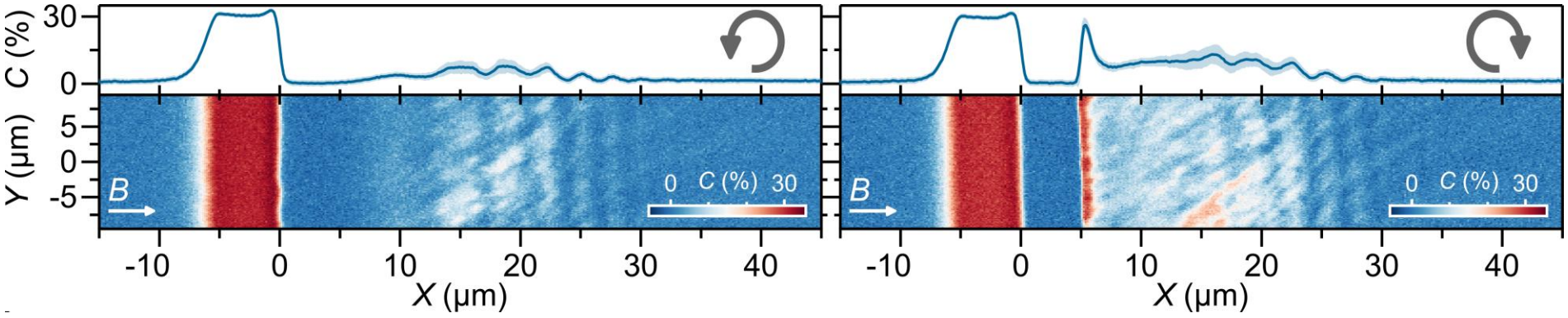




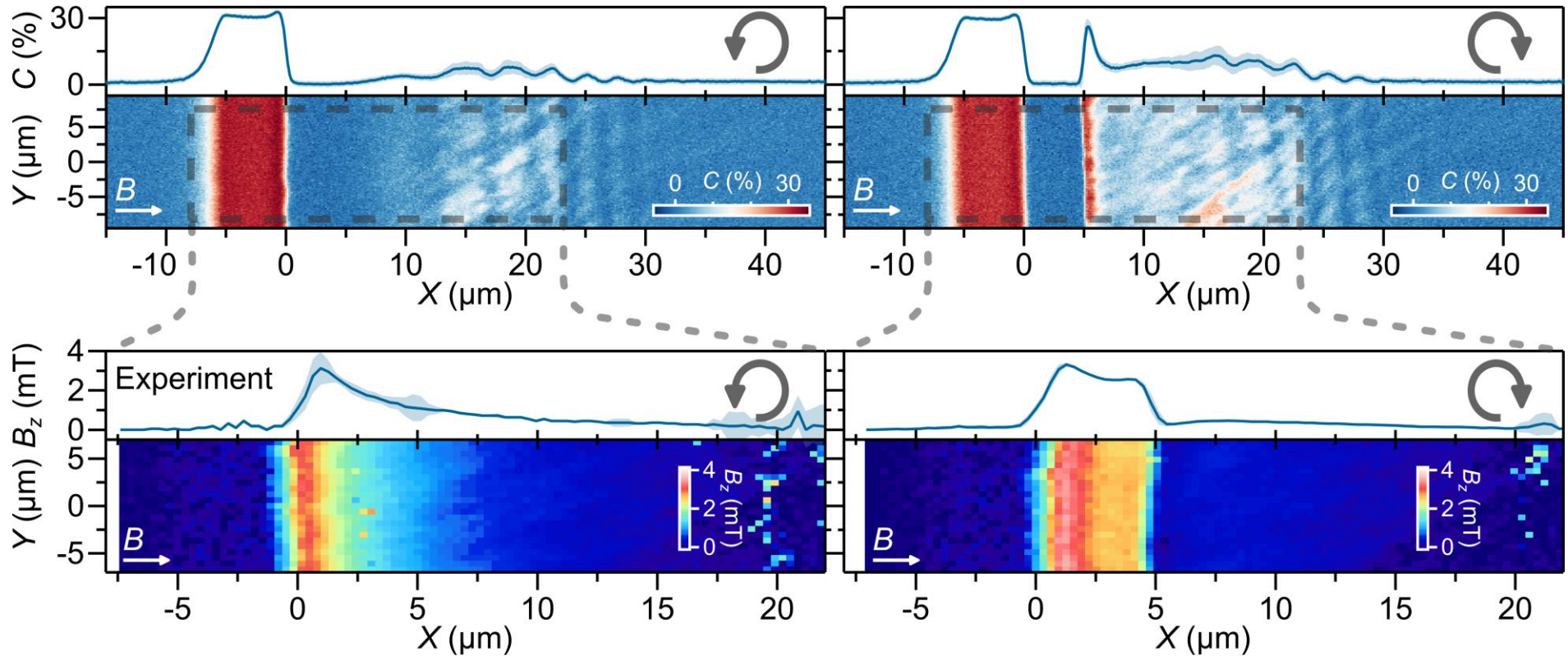
Bistability at the edge: field-control of spin textures



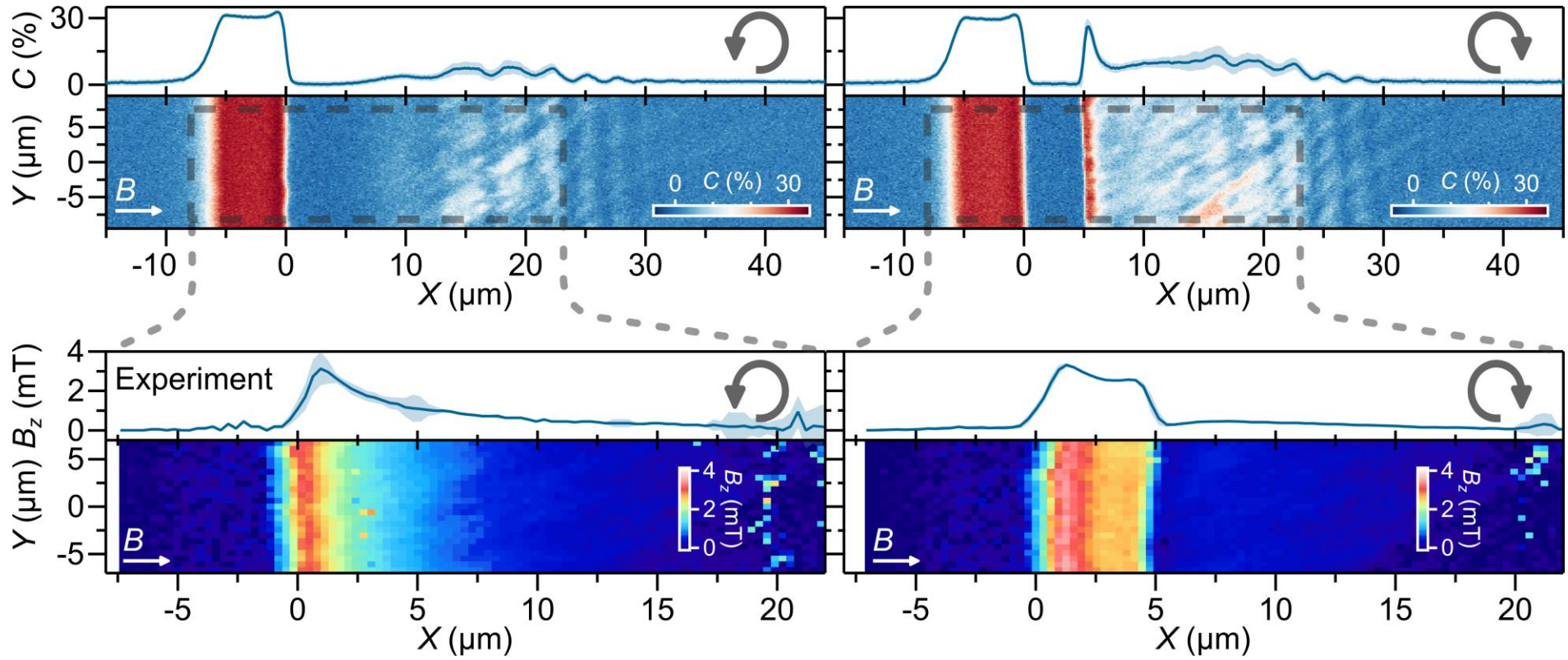




Bistability at the edge: field-control of spin textures

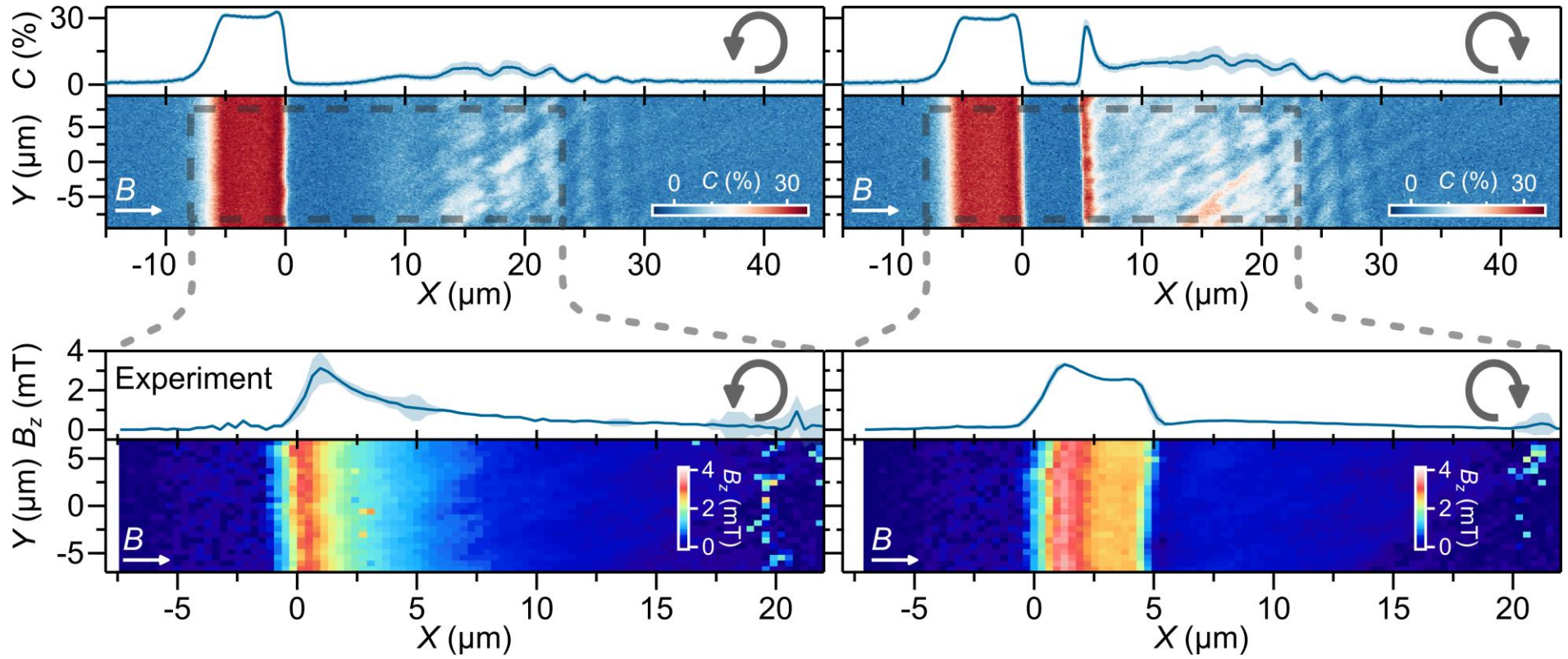


Bistability at the edge: field-control of spin textures

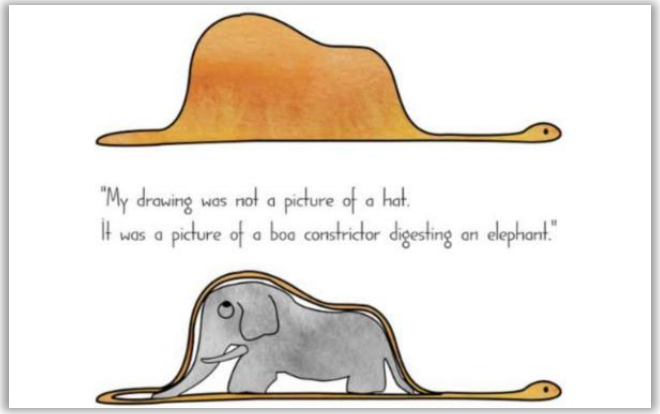




Bistability at the edge: field-control of spin textures

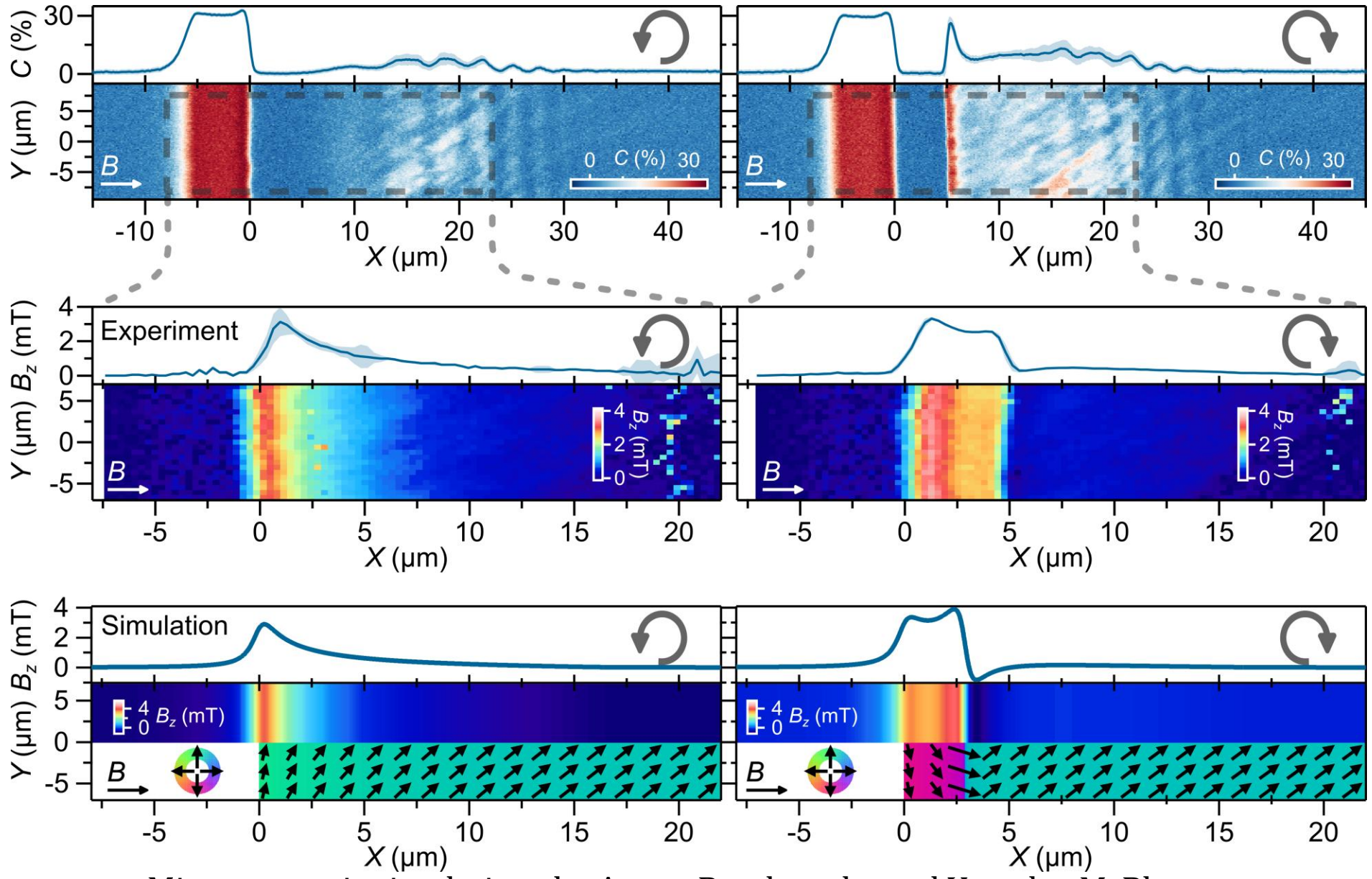






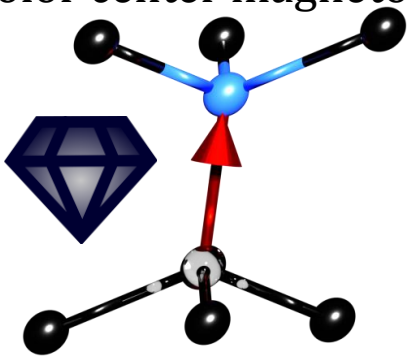
Antoine de Saint-Exupéry, The Little Prince

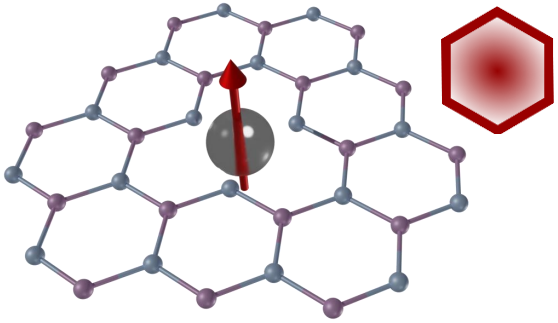
Bistability at the edge: field-control of spin textures

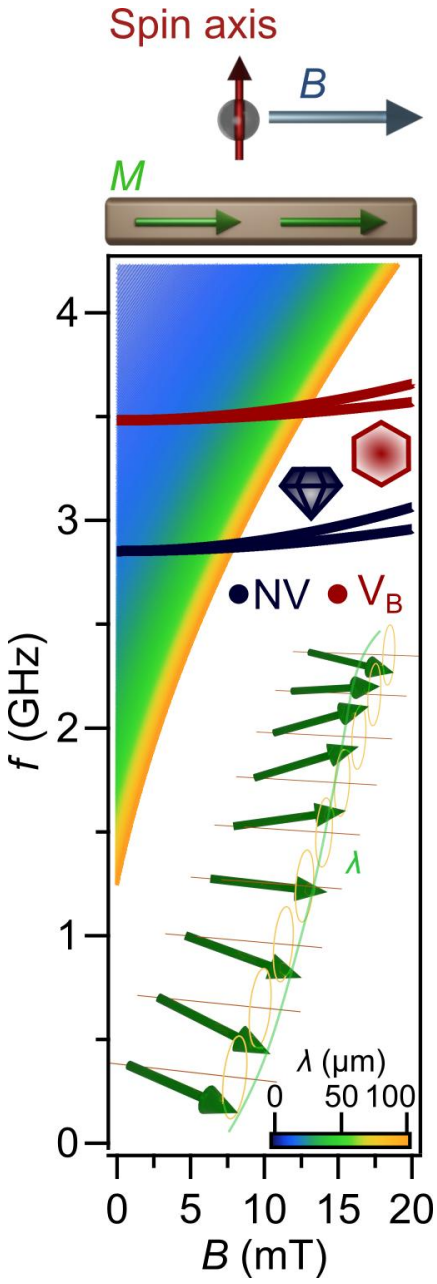


Micromagnetic simulations by Artem Bondarenko and Yaroslav M. Blanter

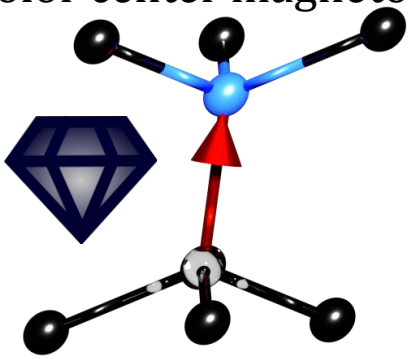
- Color center magnetometry for isofrequency spin-wave imaging.

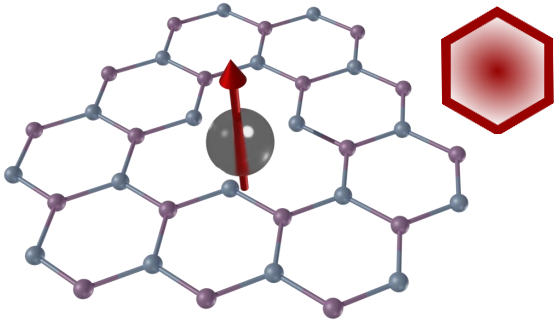




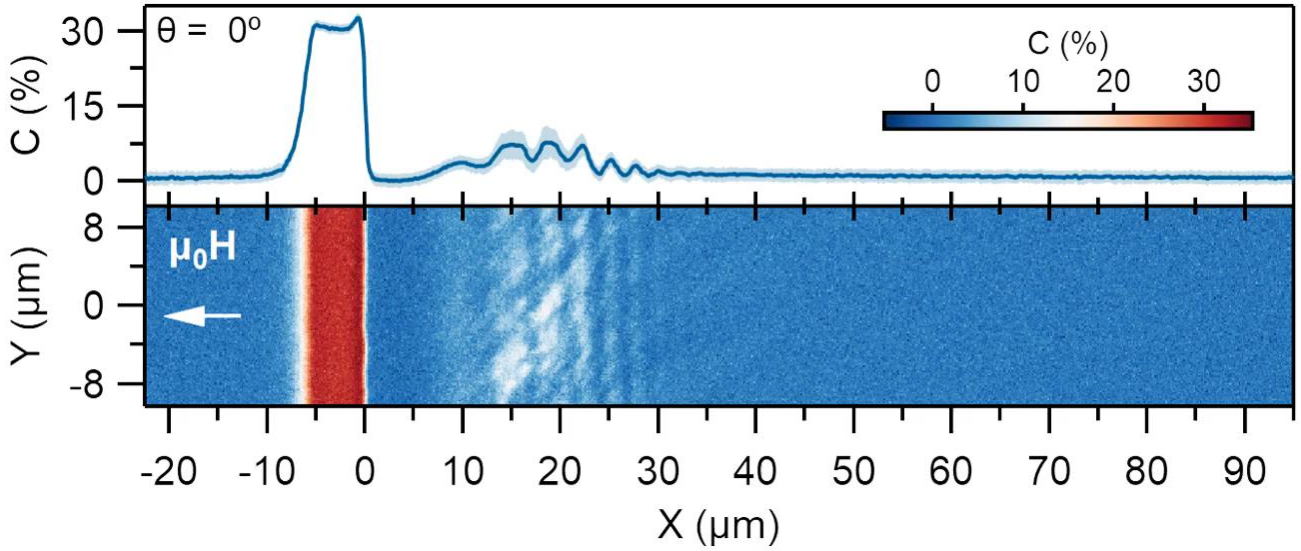


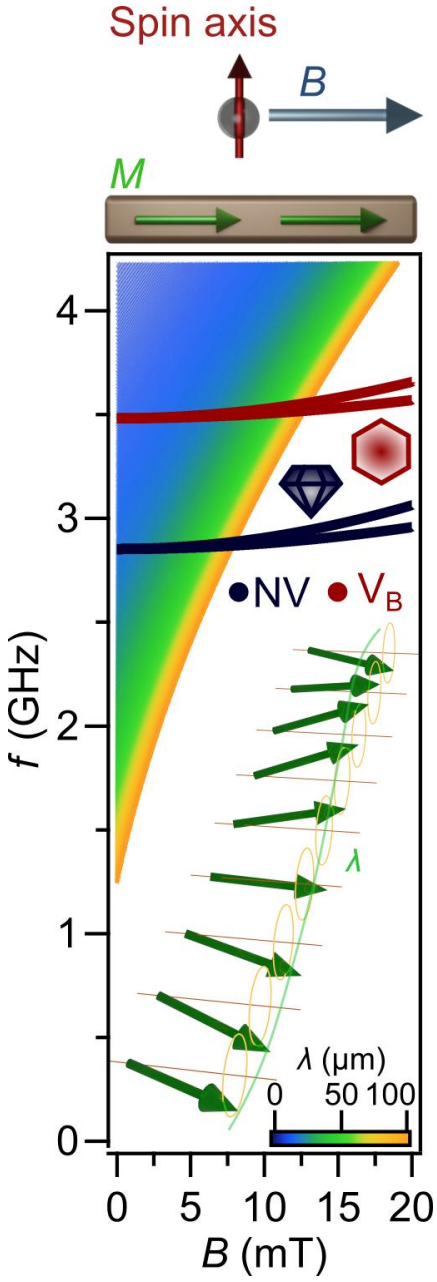
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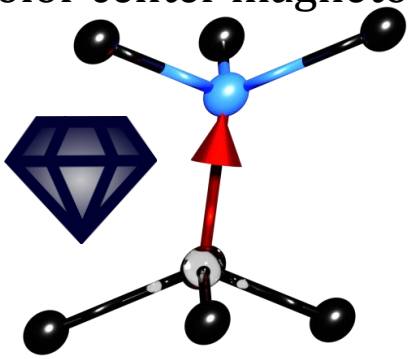


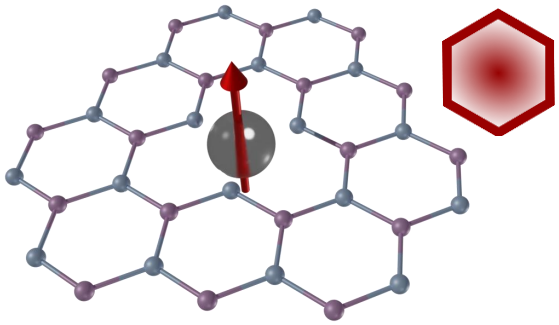
- Color center magnetometry as an ideal tool for detecting both spin-waves and local static fields, revealing the role of inhomogeneous magnetization.



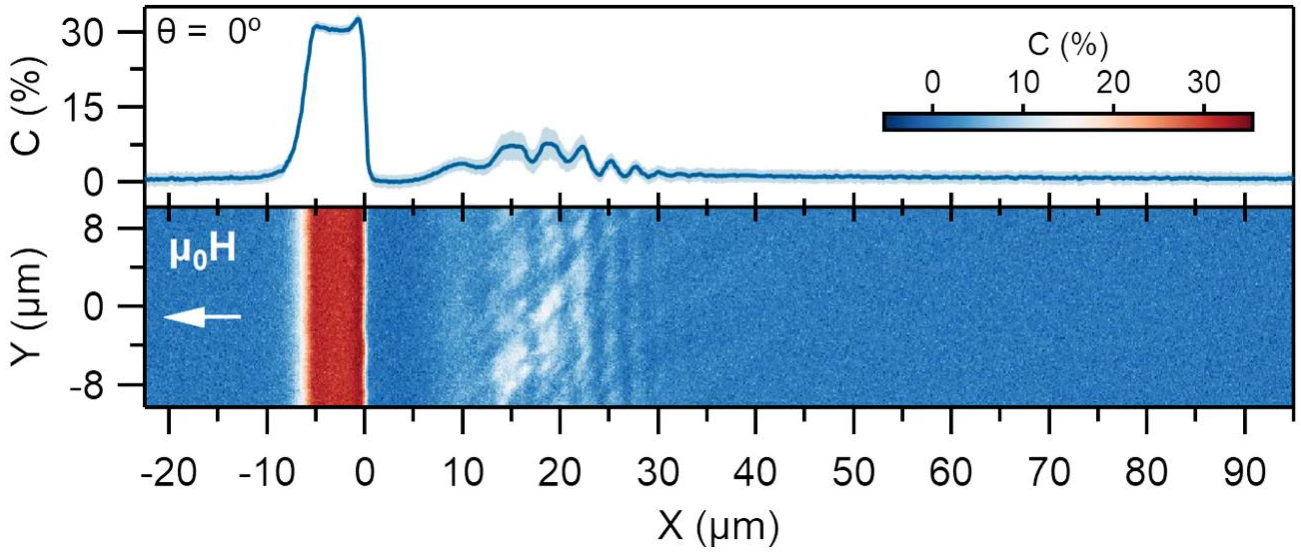


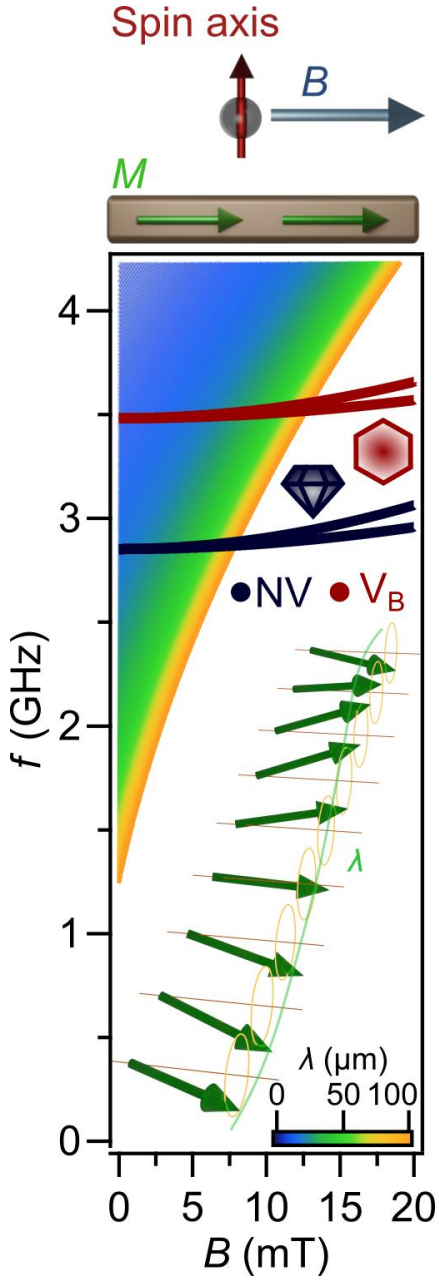
- Color center magnetometry for isofrequency spin-wave imaging.





- Color center magnetometry as an ideal tool for detecting both spin-waves and local static fields, revealing the role of inhomogeneous magnetization.





Thank you very much for your attention!