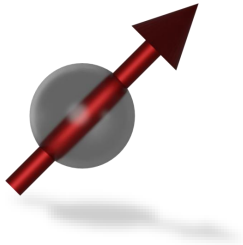
Young Research Leaders Group Workshop: Transport and transfer of angular momentum: magnons, chiral phonons and beyond

JOHANNES GUTENBERG UNIVERSITÄT MAINZ

SPIN PHENOMENA INTERDISCIPLINARY CENTER SP/CE



Spin-wave imaging using solid-state spin defects

Ingelheim, 10/06/2026

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 beach

Ingelheim, 10/06/2026

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For Today


YOUNG RESEARCH LEADERS GROUP WORKSHOP
TRANSPORT AND TRANSFER OF ANGULAR MOMENTUM: MAGNONS, CHIRAL PHONONS AND BEYOND
Workshop June 9th - 11th, 2026
Wasem Monastery, Ingelheim, Germany
SPICE
ORGANIZERS:
Verena Brehm (TU/e)
Pieter Gunnink (JGU)
Michaela Lammel (University of Konstanz)
Poster design: SuperNovaStudios, NL
INVITED SPEAKERS:
Kyongmo An (CBNU)
Silvia Damerio (ICMAB)
Vivek Dwij (Radboud University)
Laëtitia Farinacci (University of Würzburg)
Joren Harms (University of Konstanz)
Rhea Hoyer (University of Münster)
Lisa-Marie Kern (MIT)
Eric Kleinhebers (UCLA)
Miina Leiviskä (FZU)
Aleksandra Lopion (University of Münster)
Samuel Mañas Valero (UV)
Léo Mangeolle (TUM)
Hugo Merbouche (CEA)
Lorena Niggli (University of Basel)
Paul Nöel (IPCMS)
Mike Pols (ETH Zürich)
Giacomo Sala (University of Geneva)
Richard Schlitz (University of Konstanz)
Sanchar Sharma (UAM)
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Markus Weissenhofer (UU)
Na Wu (MPSD)
The Spin Phenomena Interdisciplinary Center aims to bring together scientists of varying seniority and disciplines in spin related research to break down scientific barriers and foster emergent areas of research.
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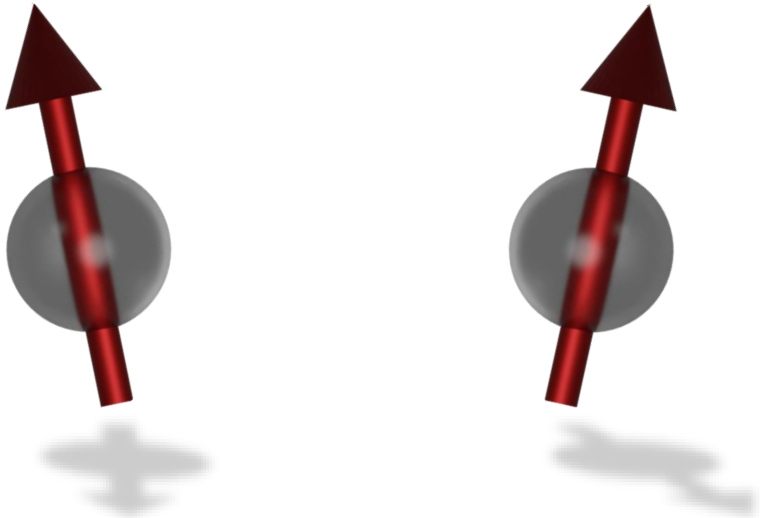
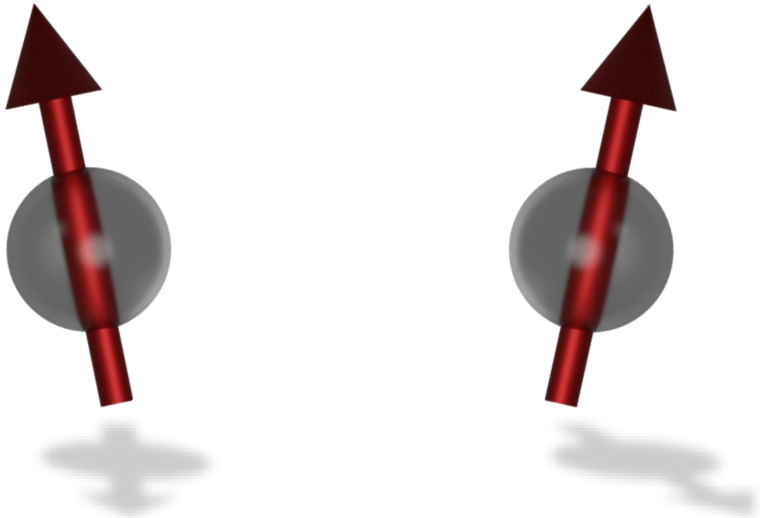


For Today

Spin defects for quantum sensing



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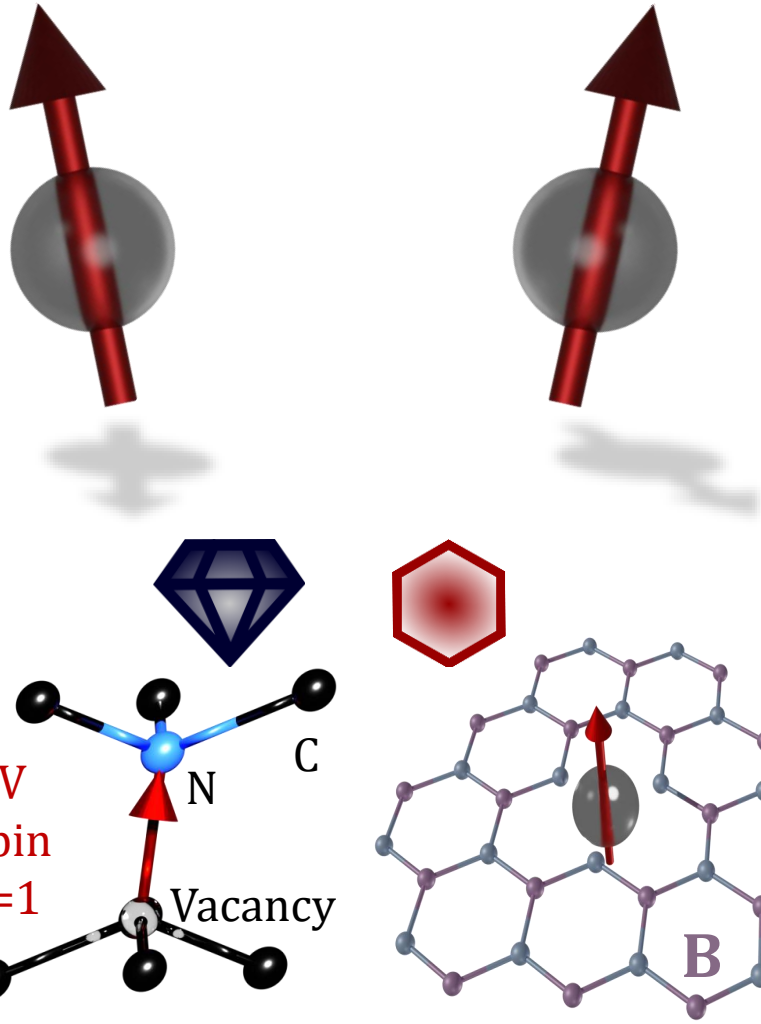
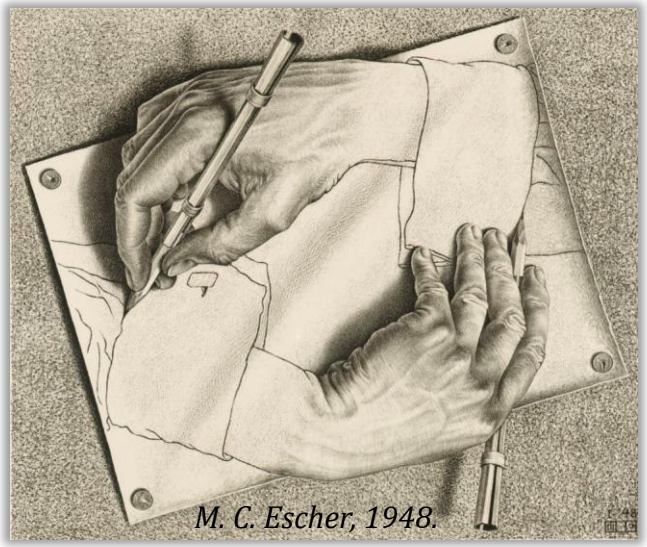
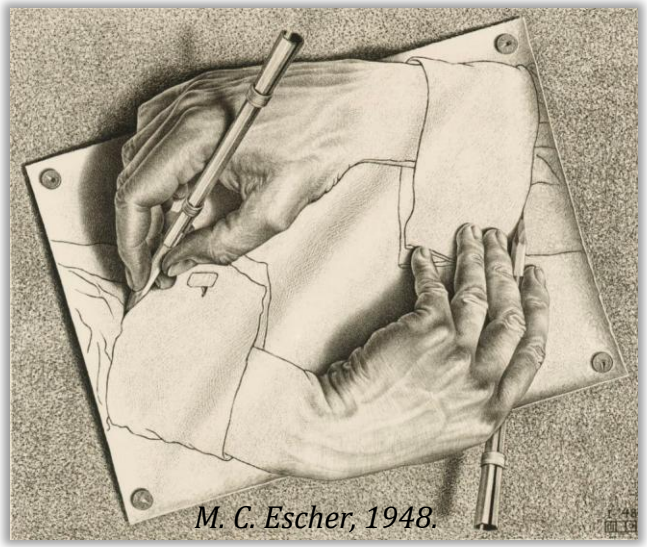


Low-Dimensional Magnetism



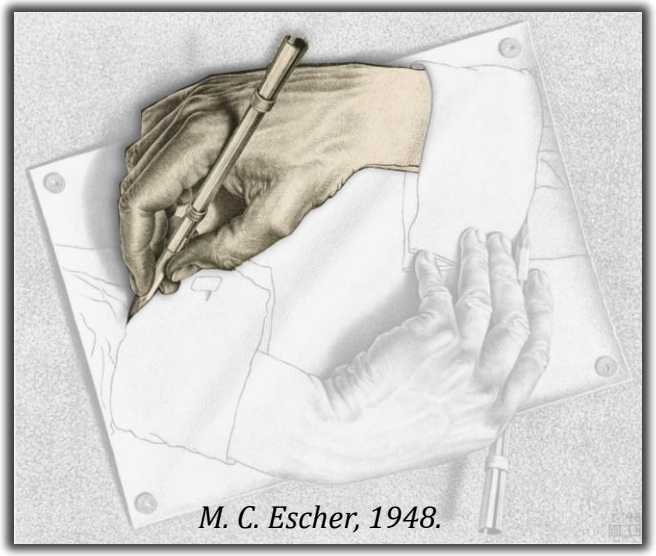
Low-Dimensional Magnetism

Interplay between materials growth and low-dimensional magnetism



About my research: Spins and Materials

Interplay between materials growth and low-dimensional magnetism



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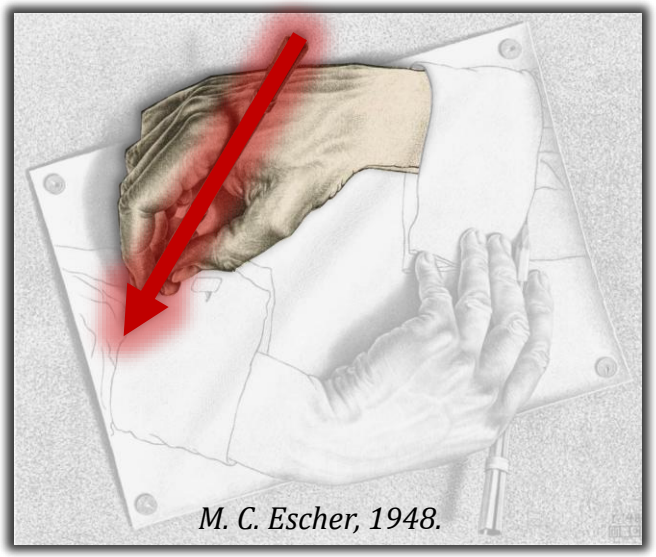
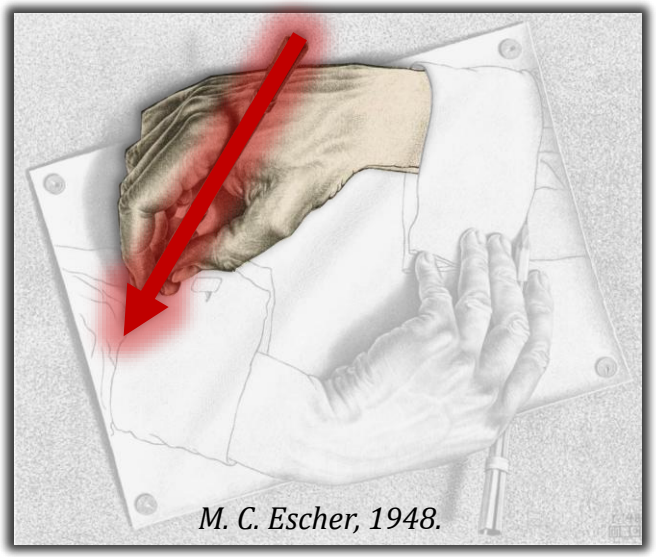


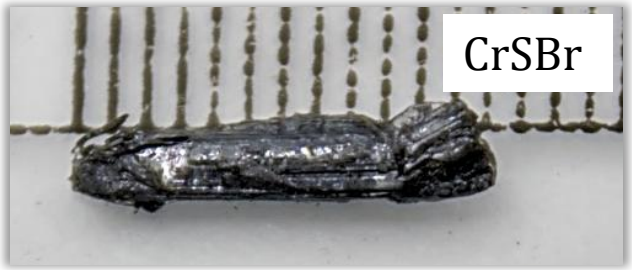
From Chemistry & Materials Science

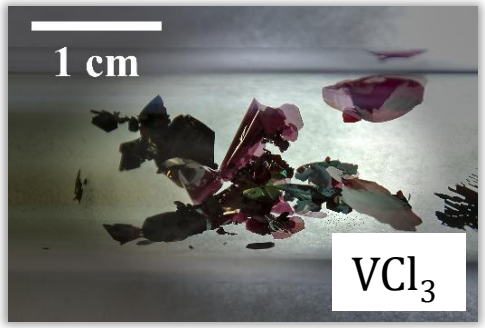
Solid state chemistry (inorganic compounds)
Coordination chemistry (molecular magnetism)
Thin-film growth (spintronics)

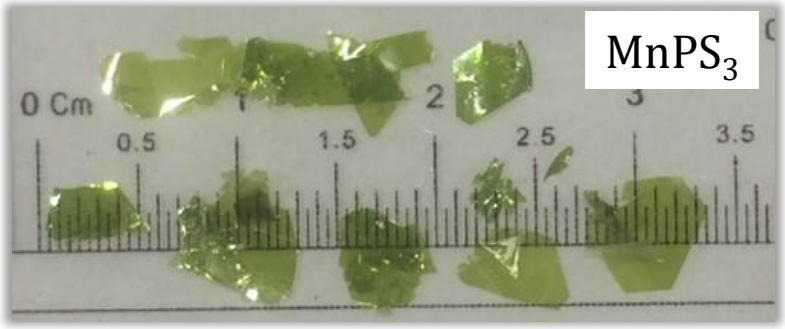
Interplay between materials growth and low-dimensional magnetism



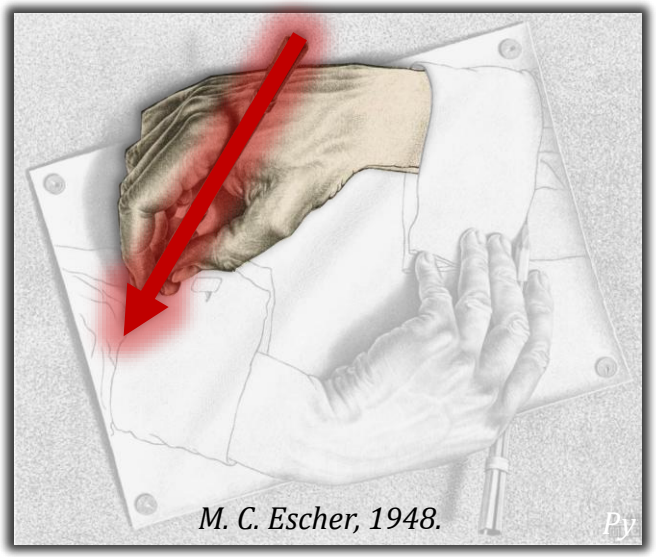
From Chemistry & Materials Science



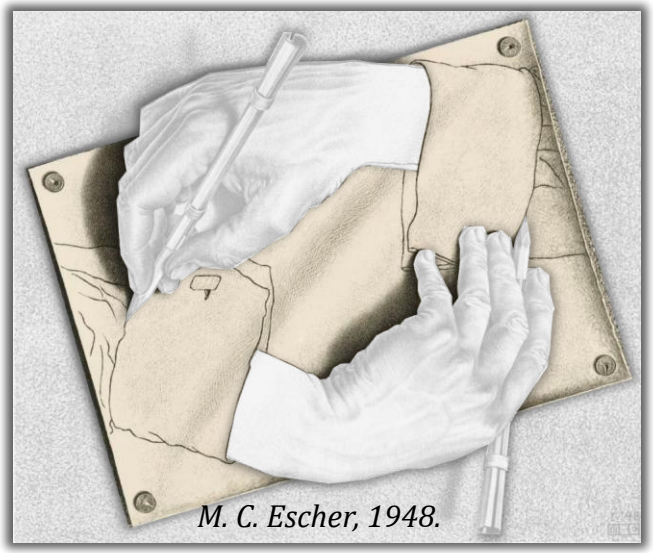




van der Waals magnets and magnetic thin-films

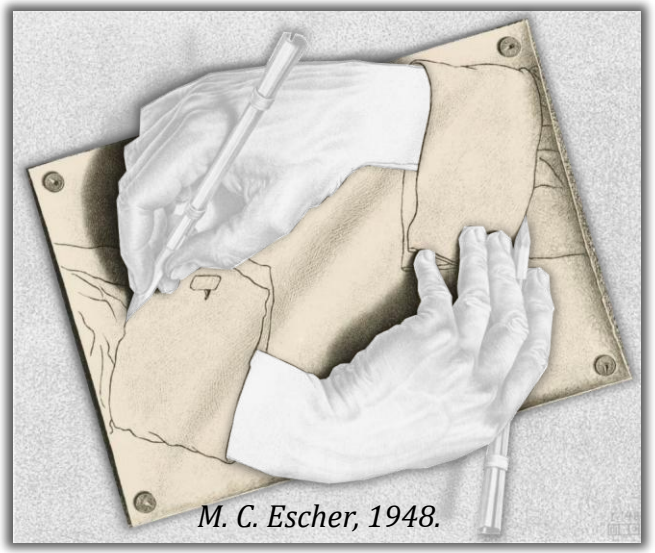


To Low Dimensional Magnetic systems



To Low Dimensional Magnetic systems

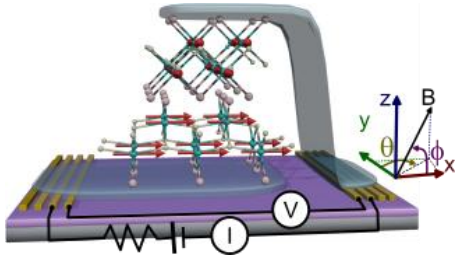
- 2D materials (Valencia, E. Coronado)
- Spin waves in thin-films (Delft, T. van der Sar)

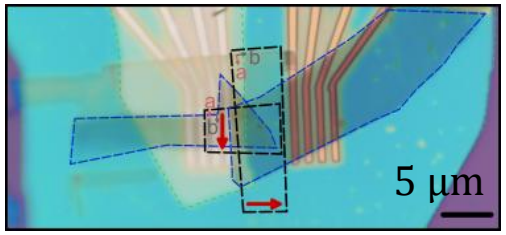


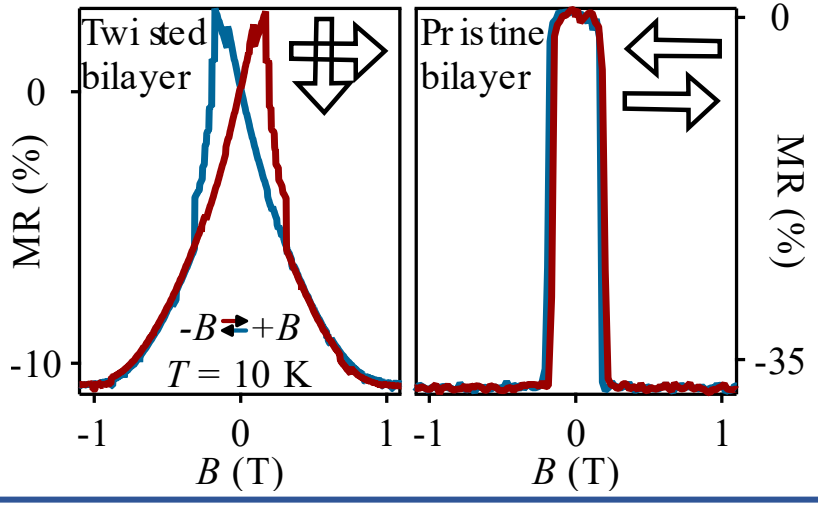
To Low Dimensional Magnetic systems

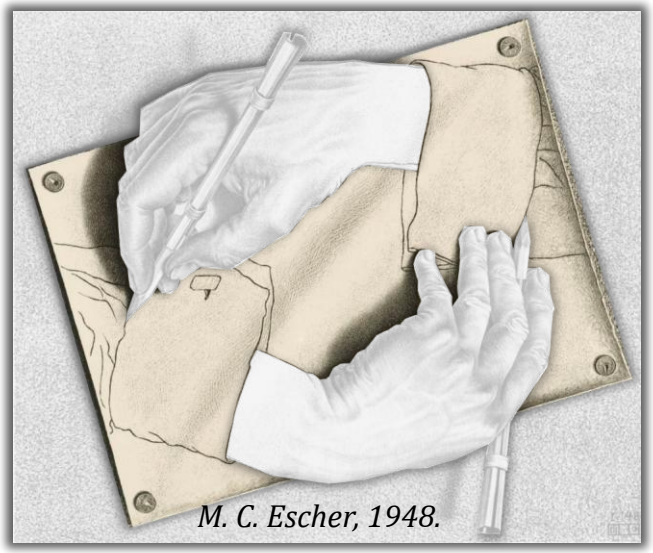
- 2D materials (Valencia, E. Coronado)
- Spin waves in thin-films (Delft, T. van der Sar)

Probing and twisting 2D van der Waals magnets



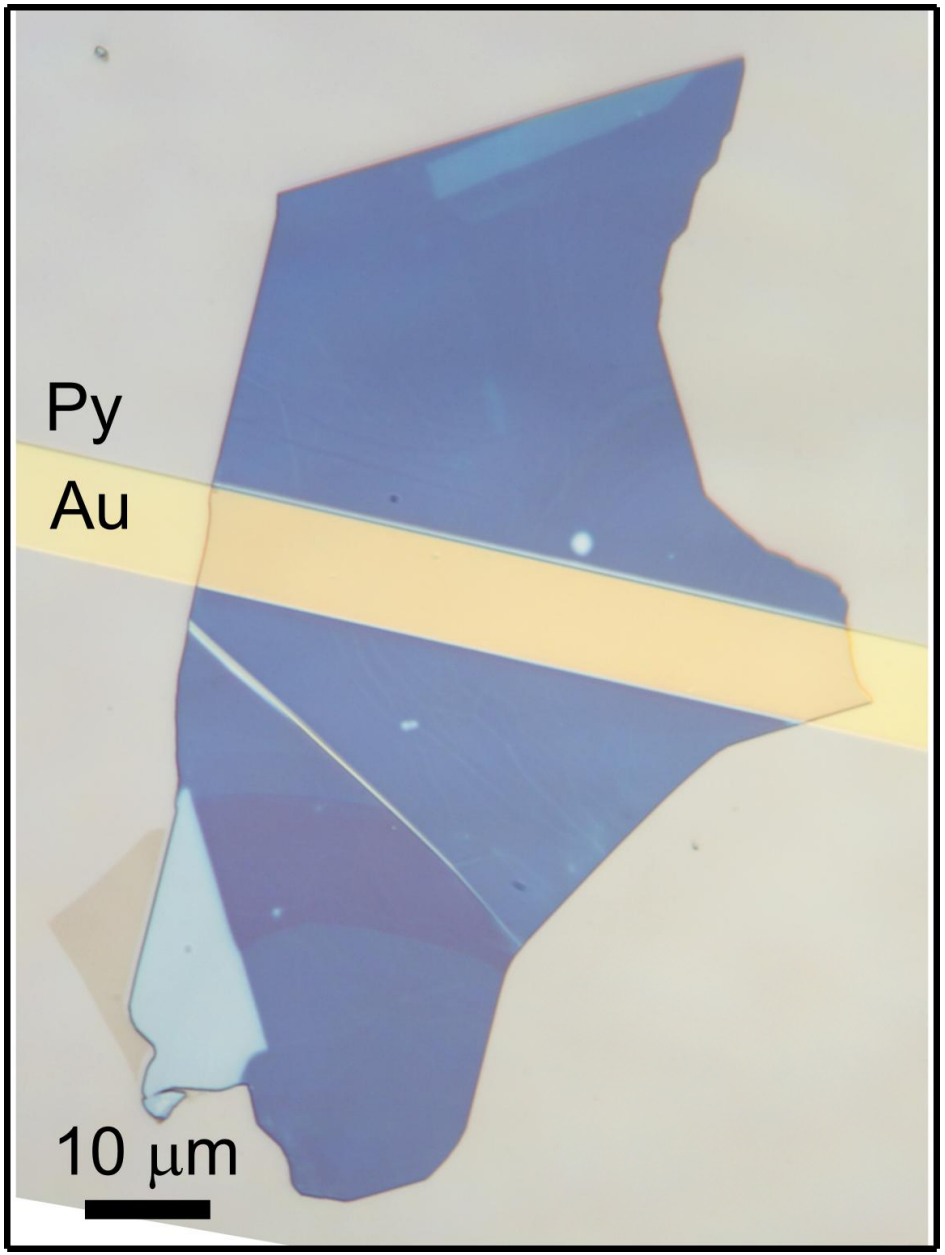




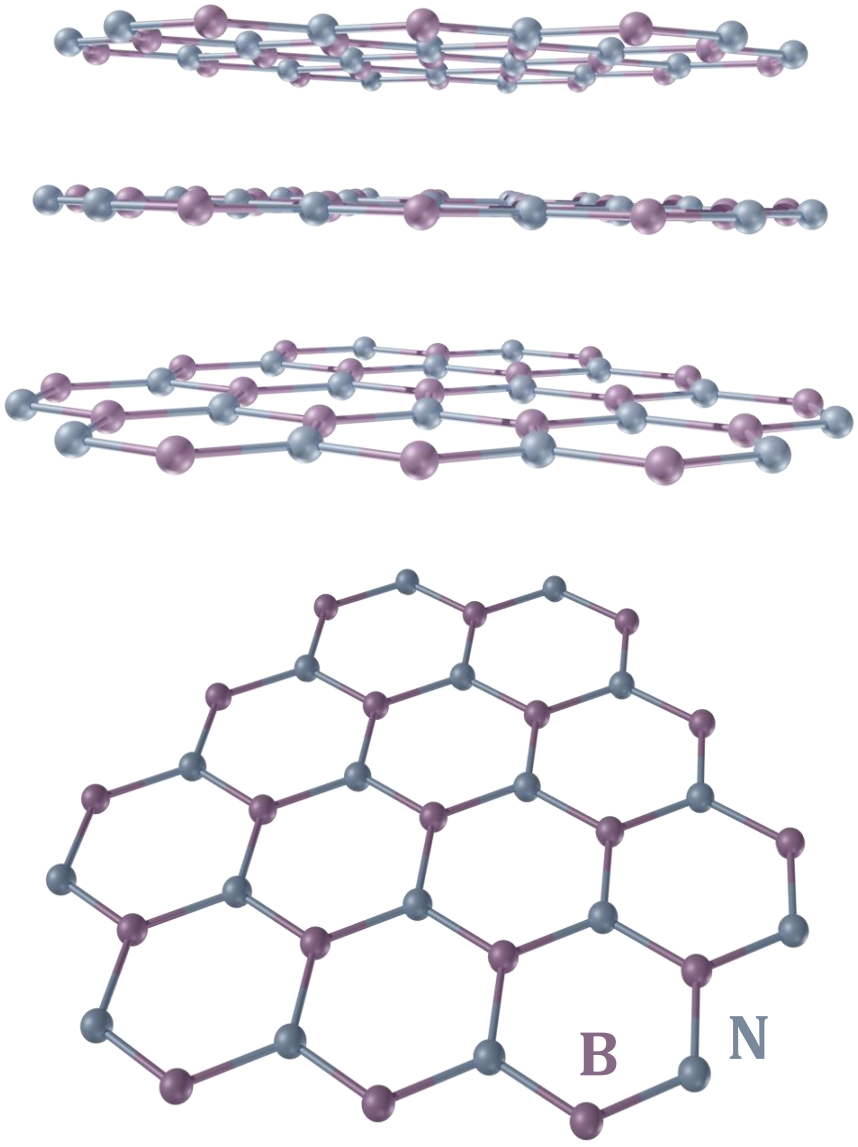


Advanced Materials 34, 2204940, 2022
Advanced Materials 35, 2307195, 2023
Nature Materials 23, 212, 2024
Advanced Materials 37, 2415774, 2025

For Today



hexagonal Boron Nitride



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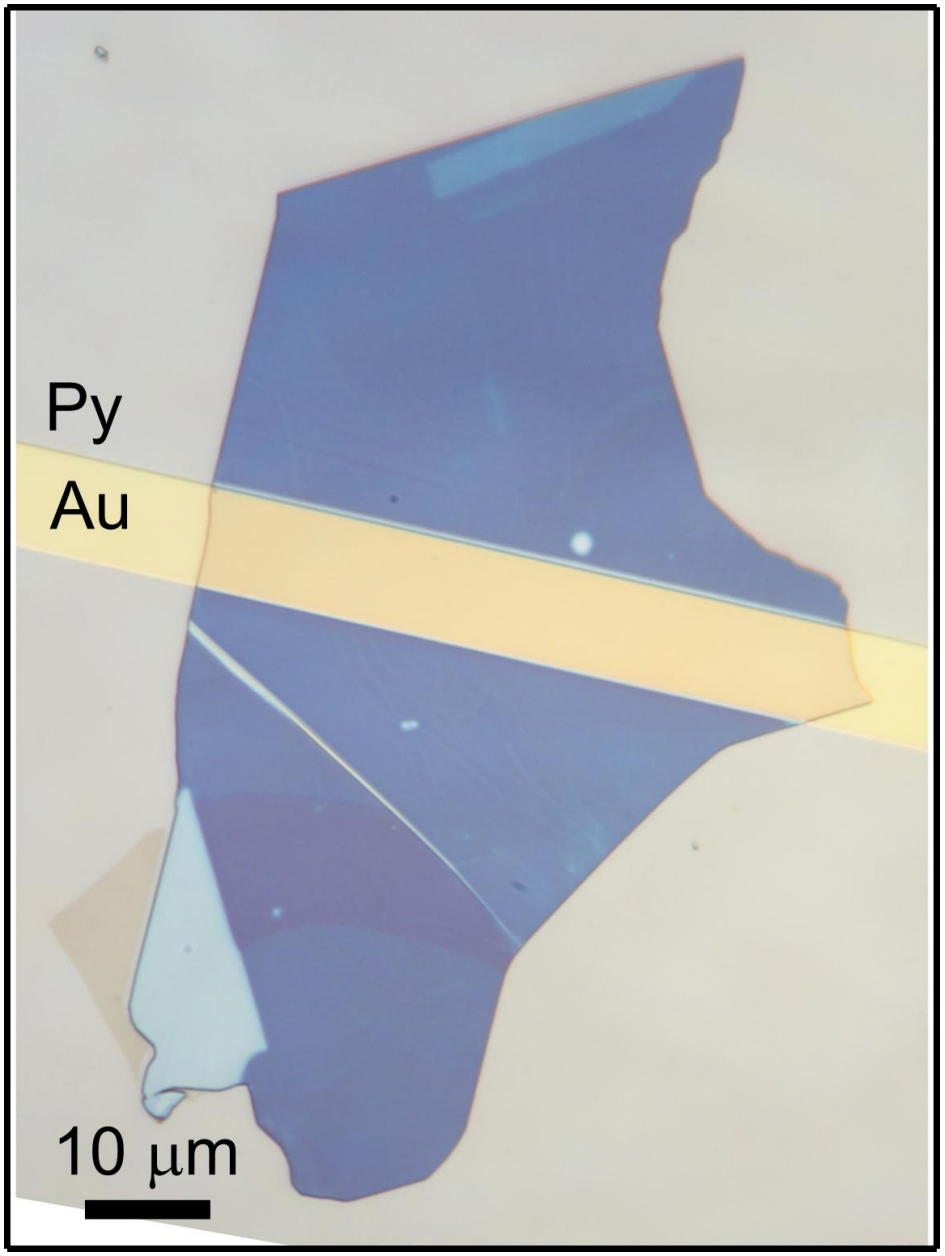
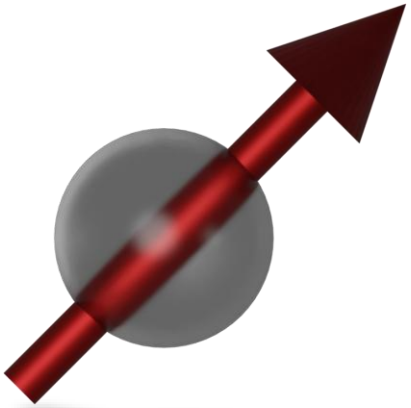
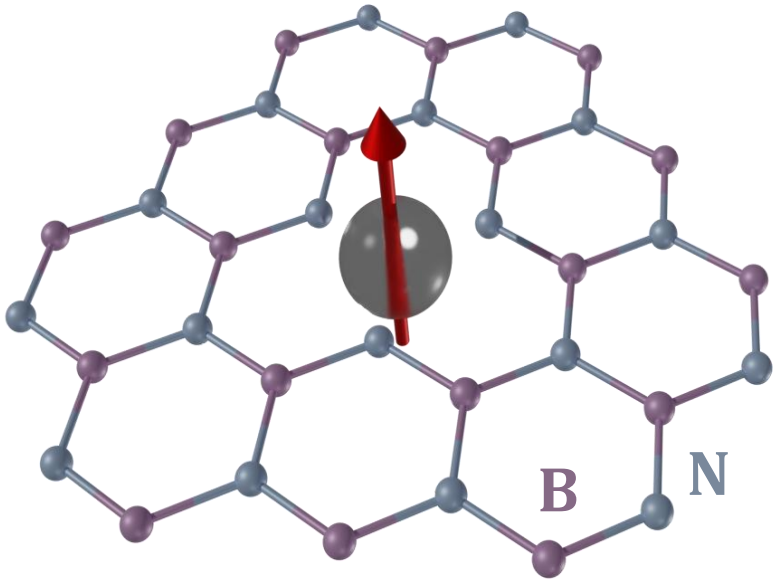


Spin defects





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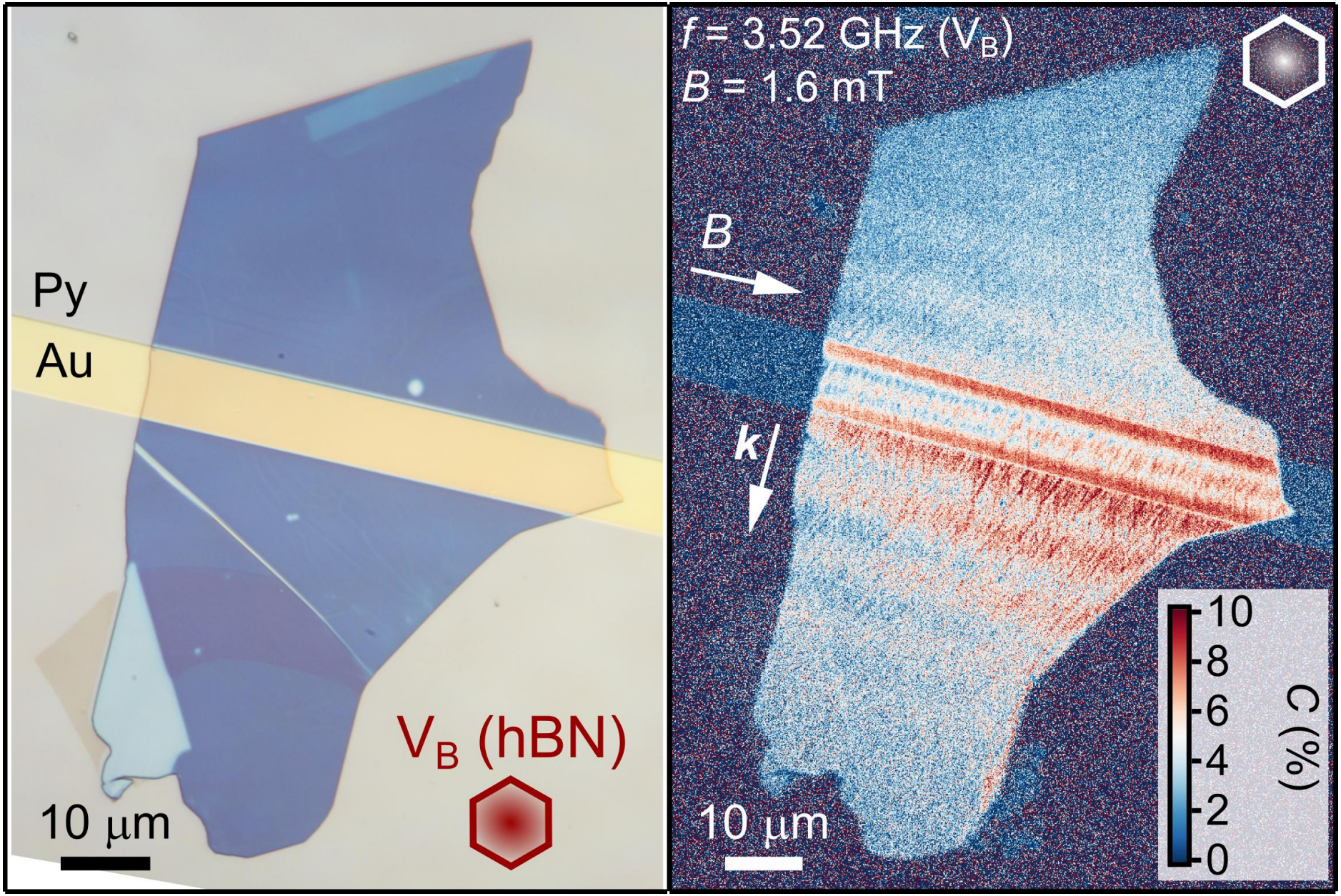
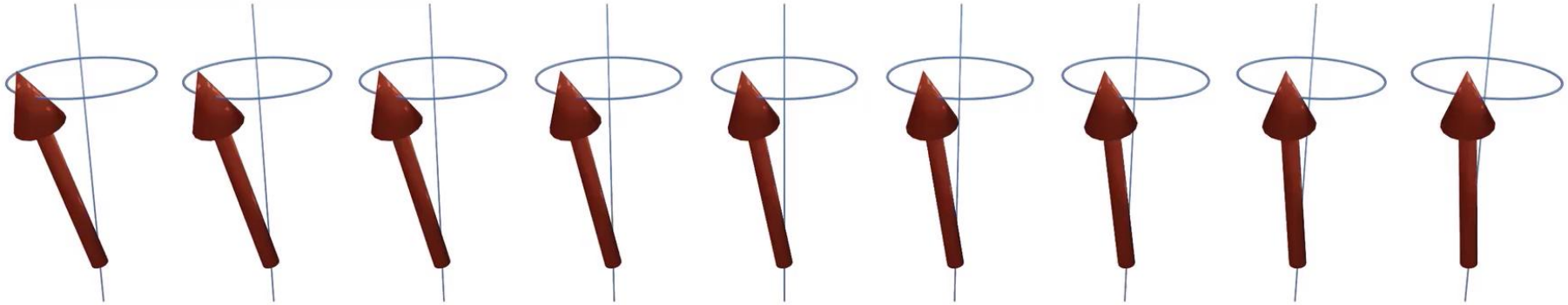


Dynamic magnetization

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

All spins in-phase



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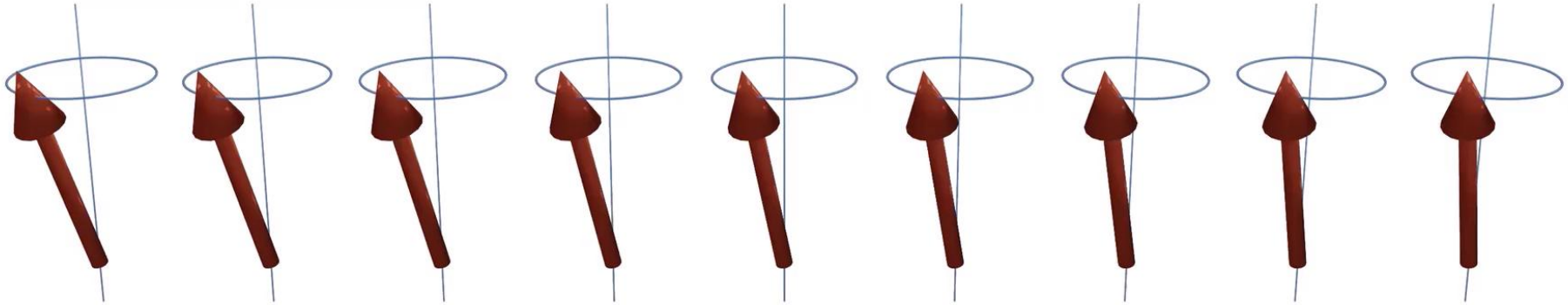
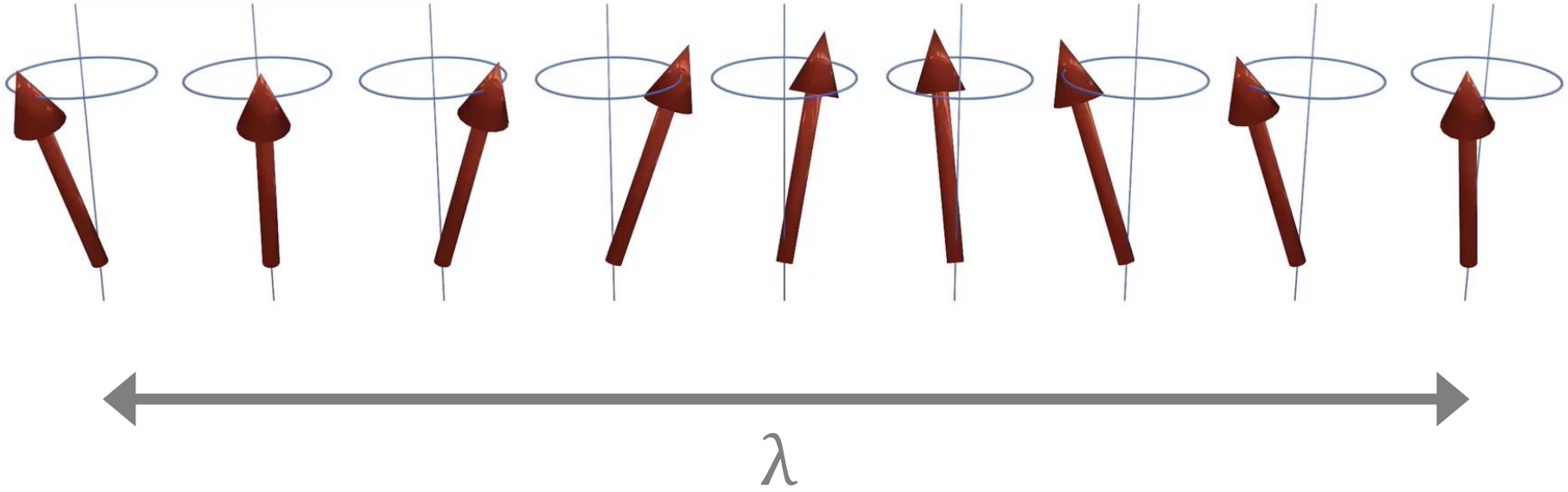


Spin waves with finite $\vec{k}$

Dephasing between spins

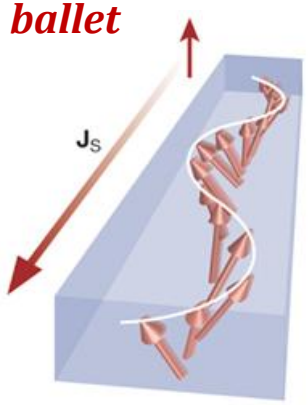


Magnon spintronics

Magnons:

Wave-like excitations of spins in magnets

The quantum ballet



Kajiwara et al., Nature 2010

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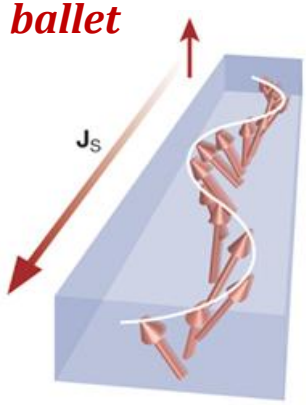

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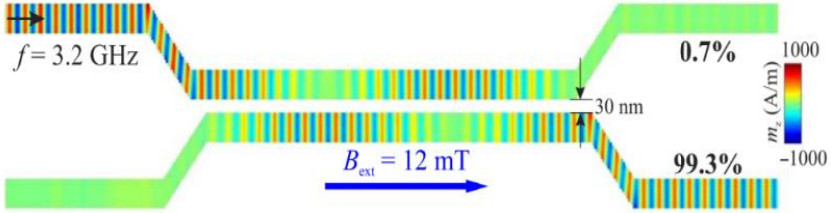
Key drive: information technology



Wang et al, Sci. Adv. 2018
Chumak et al, IEEE Trans. Magn 58, 6 2022
Pirro et al, Nat. Rev. Mater. 6 1114, 2021

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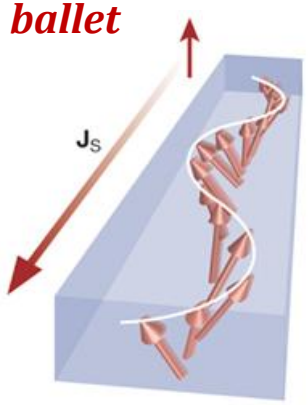
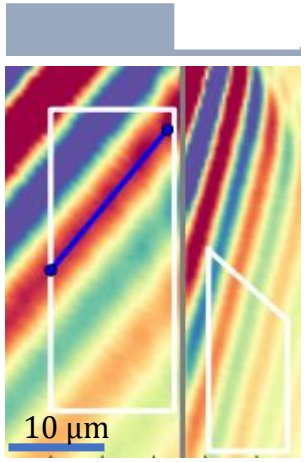


Kajiwara et al., Nature 2010

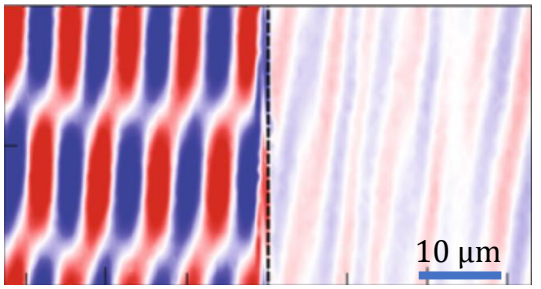
Important goal: spin-wave control

Thickness control



Stigloher et al., Phys. Rev. Lett. 2016

Auxiliary magnetic materials



Qin et al., Nat. Comm. 2021

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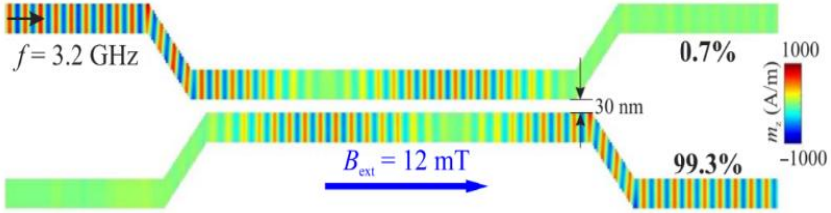

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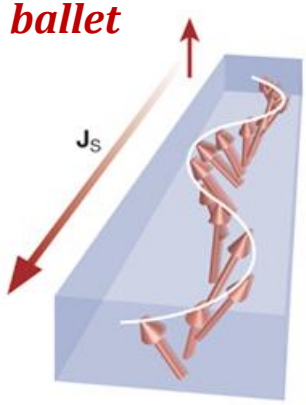

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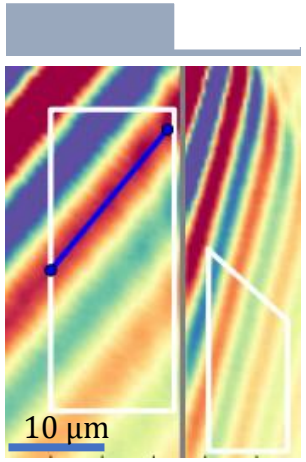

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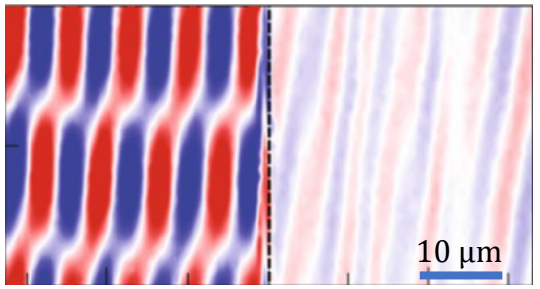

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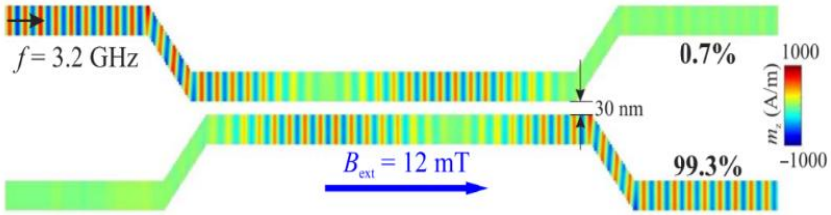


Wang et al, Sci. Adv. 2018
Chumak et al, IEEE Trans. Magn 58, 6 2022
Pirro et al, Nat. Rev. Mater. 6 1114, 2021

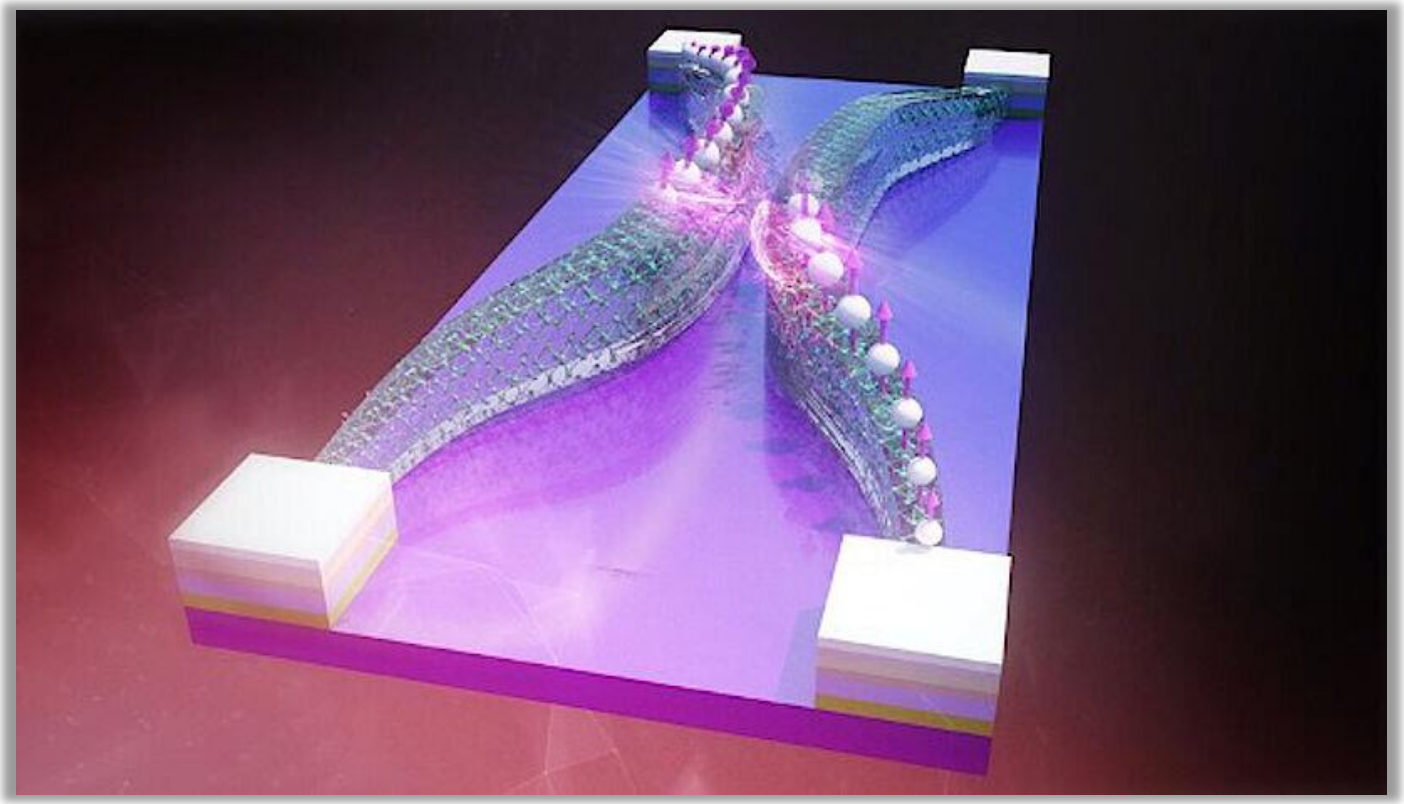
+ many active research topics

- **Interaction with metals, phonons, superconductors**
- **2D magnets**

Magnon spintronics

Goal:

replacing electric currents by spin currents



Nat. Electronics 3, 765, 2020

Magnon spintronics

Goal:

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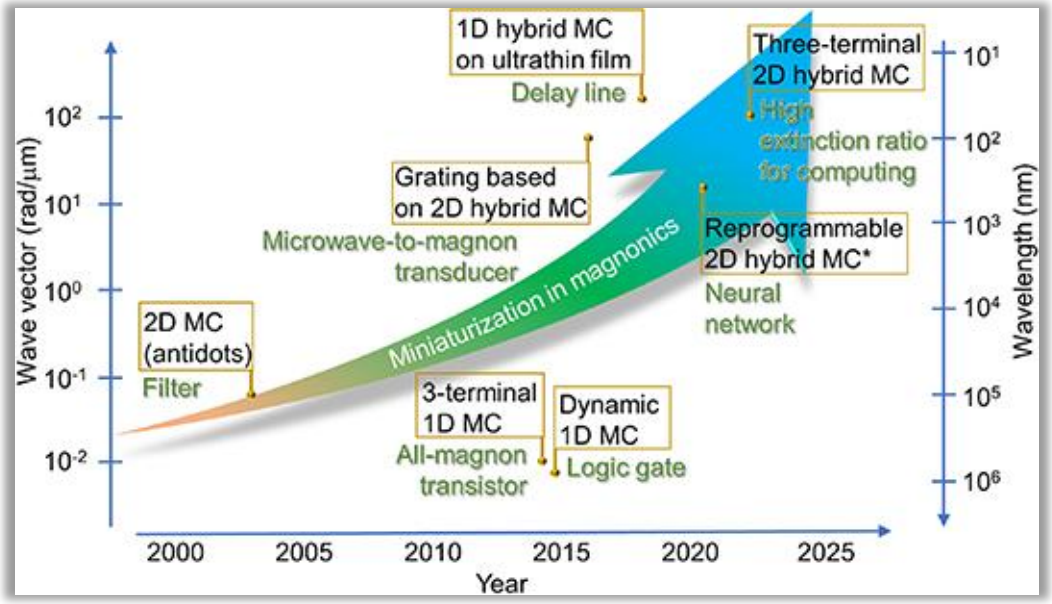
Challenge:

miniaturization



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

van der Waals magnets for magnon spintronics

Goal:

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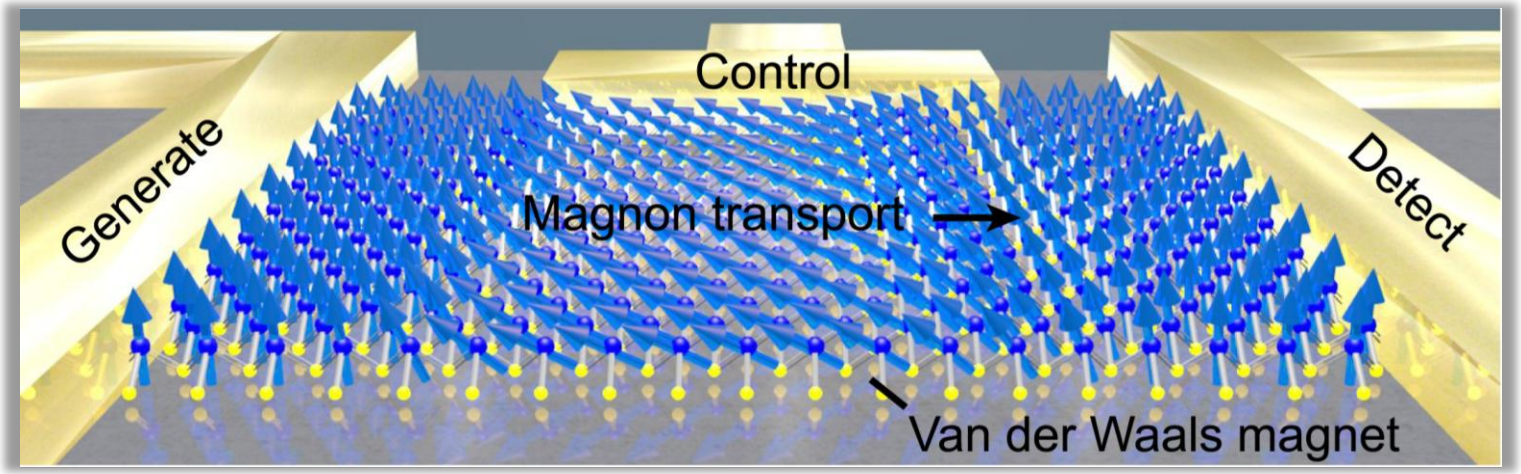
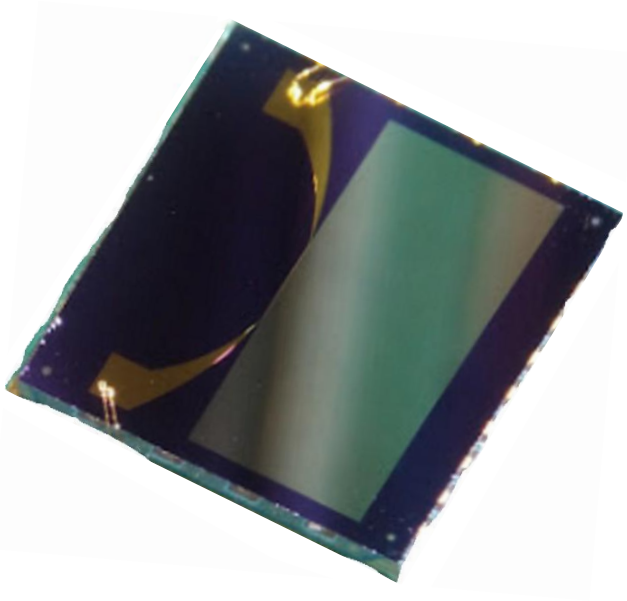
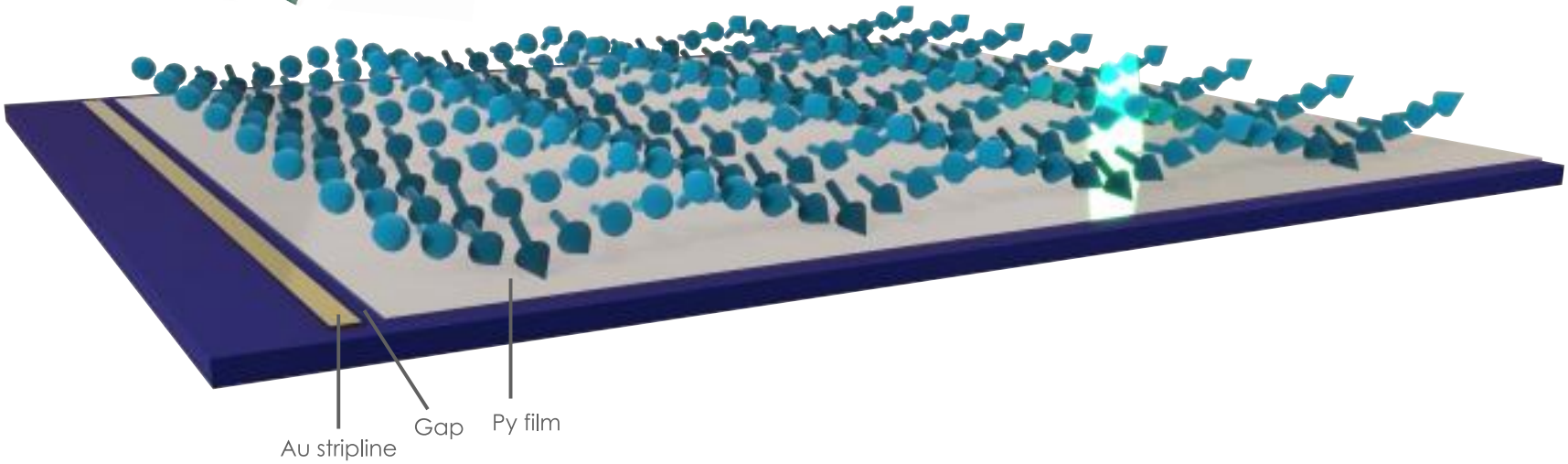


Mañas-Valero, van der Sar, Duine, van Wees, Newton 1, 1, 100018, 2025

A very simple *magnonic* device





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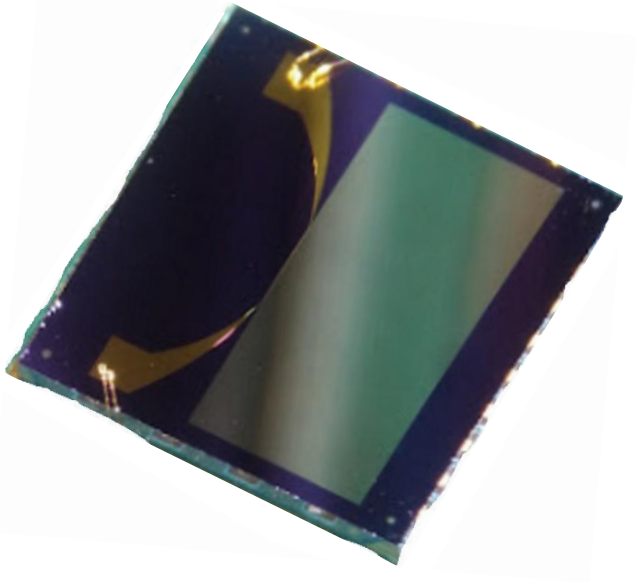
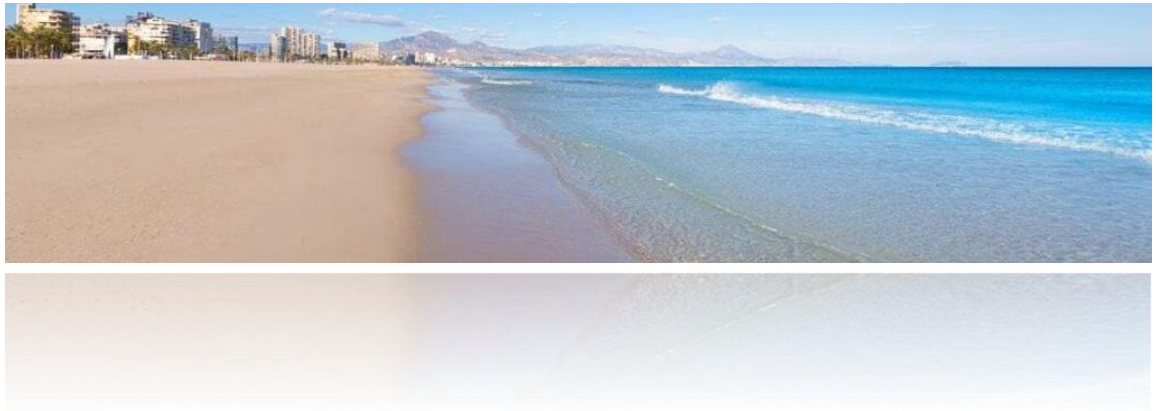
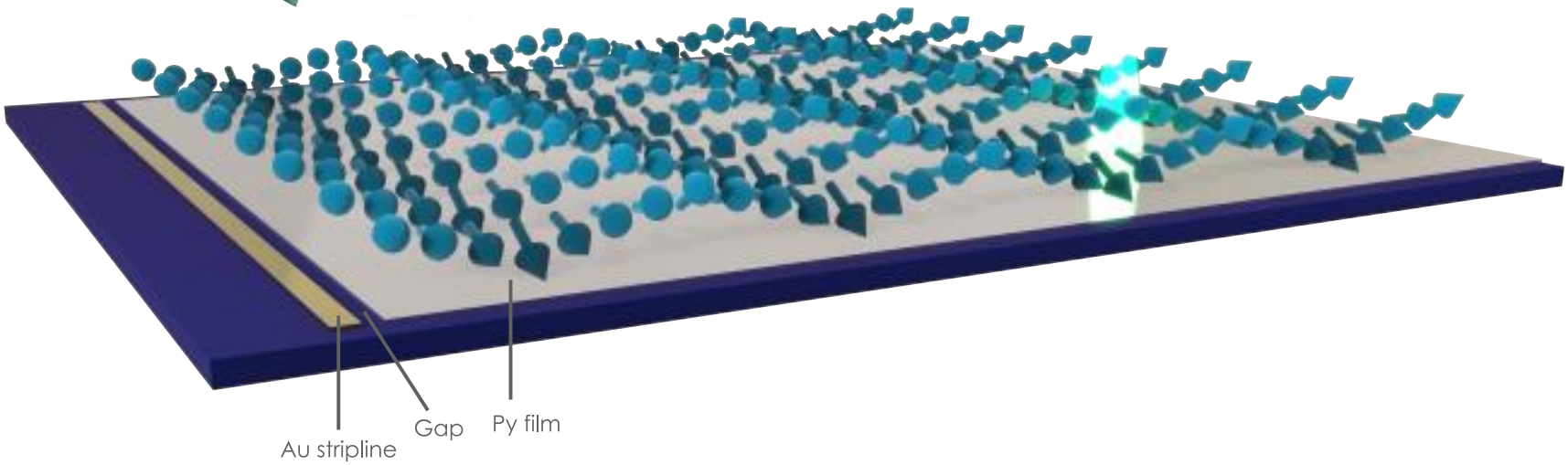
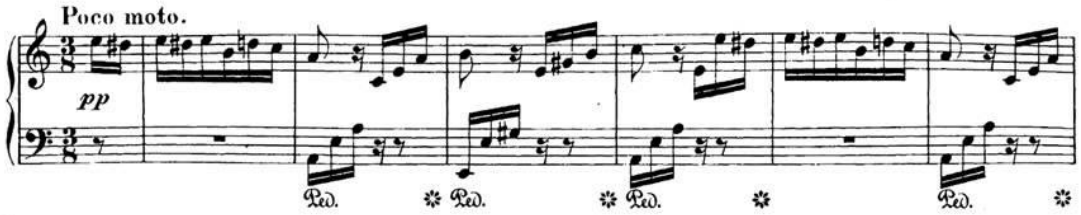


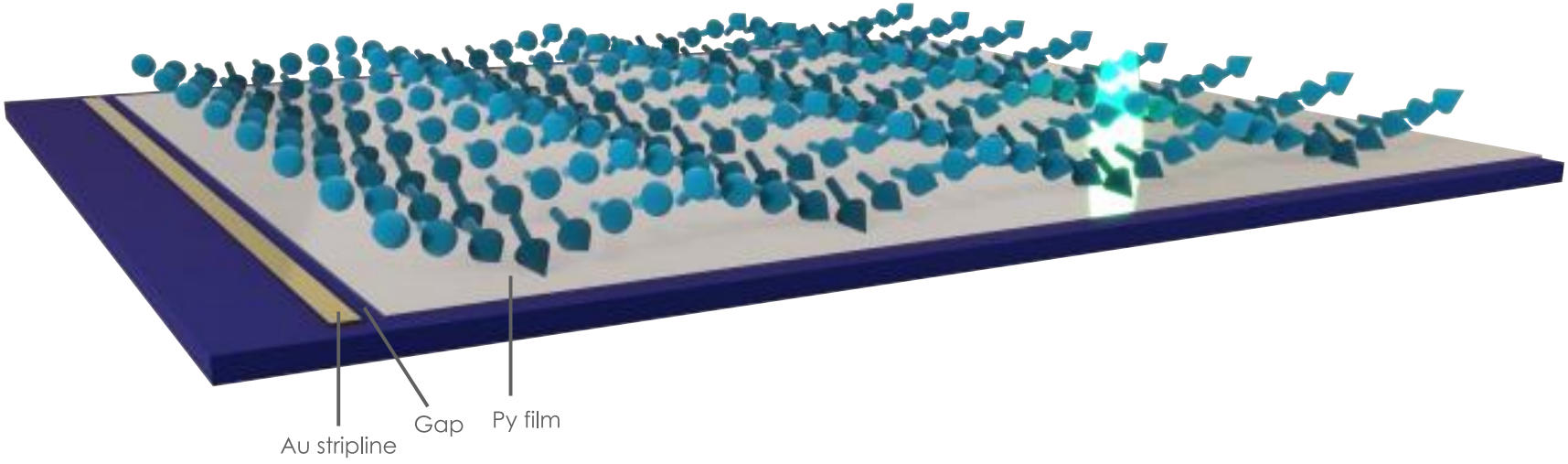




A very simple *magnonic* device

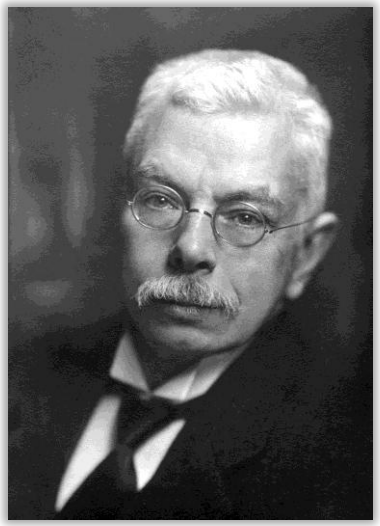
1. ***Generate f (typically, GHz regime)***



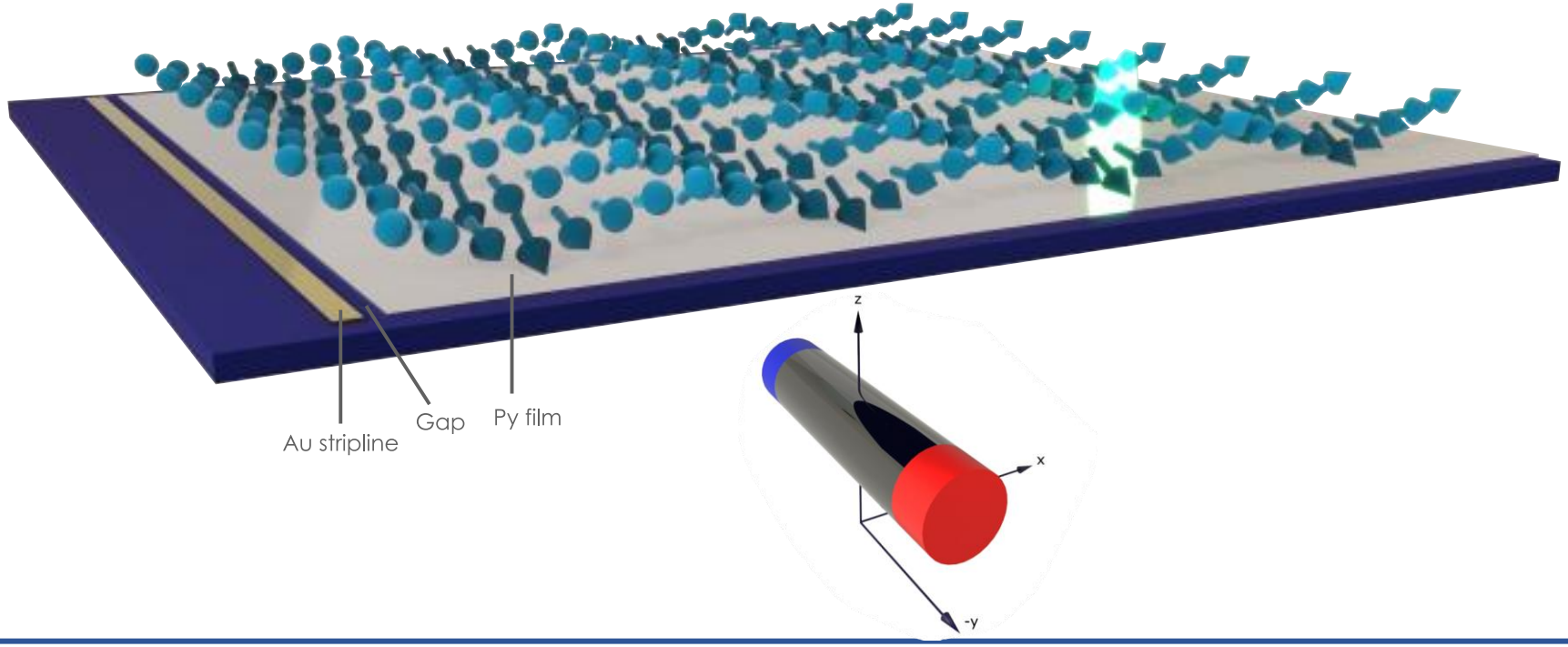


A very simple *magnonic* device

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

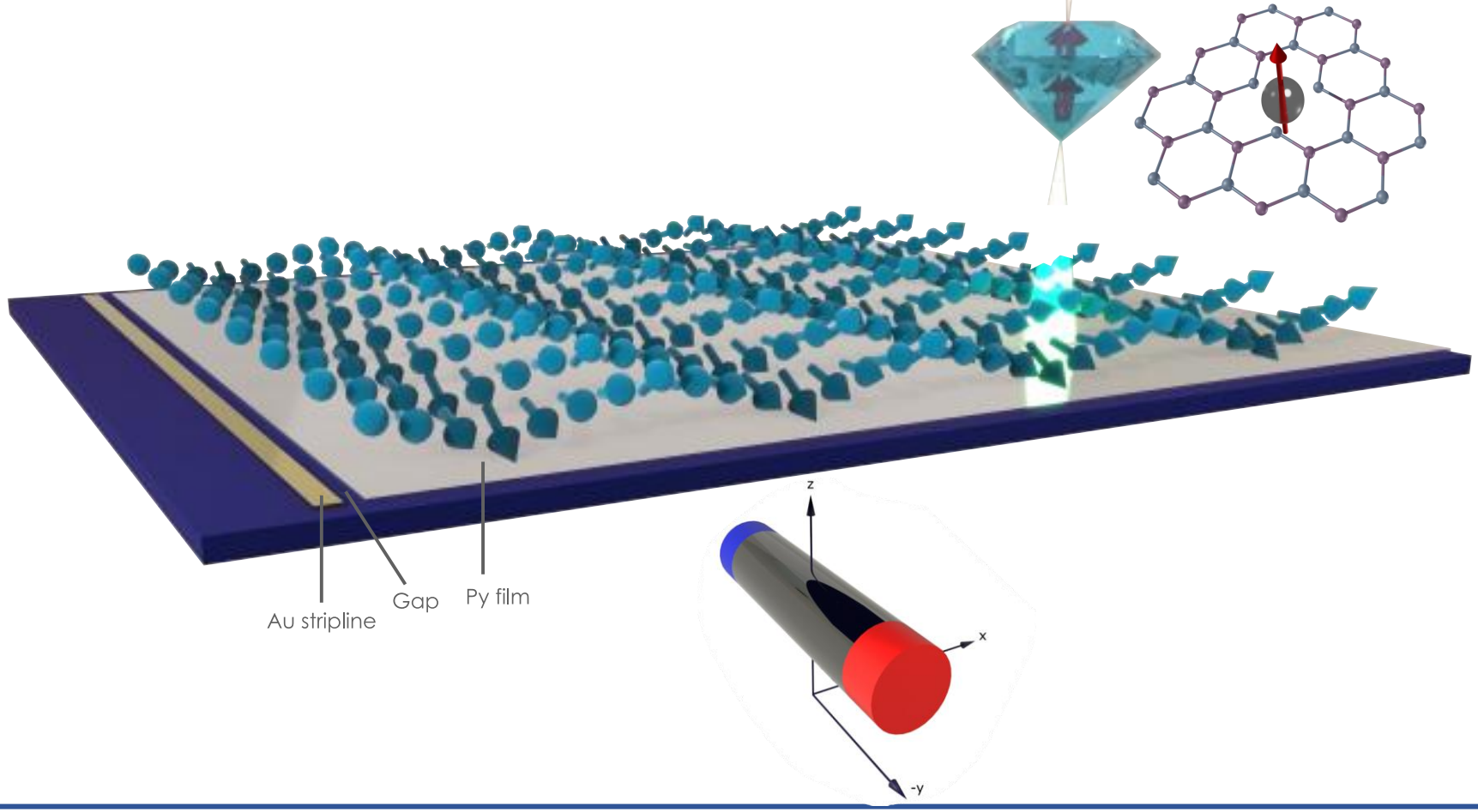


Zeeman
(1865 - 1943)



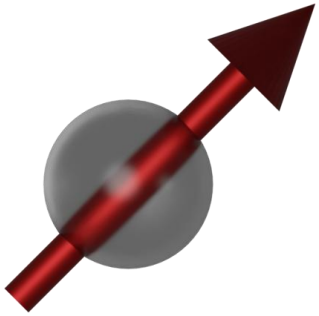
A very simple *magnonic* device

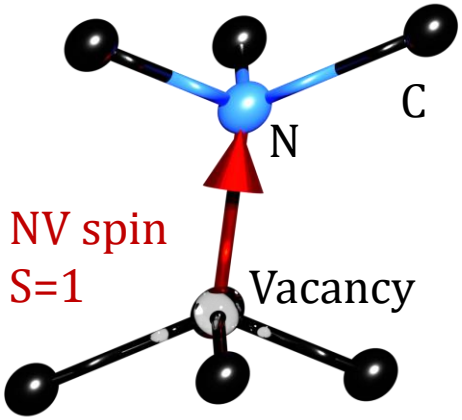
1. ***Generate***
2. ***Control***
3. ***Detect: quantum sensing with solid-state spin defects***



Quantum sensing with color centers

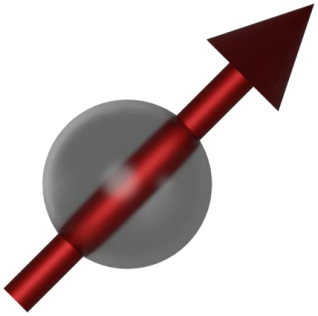
Nitrogen-Vacancy
(NV) center in diamond

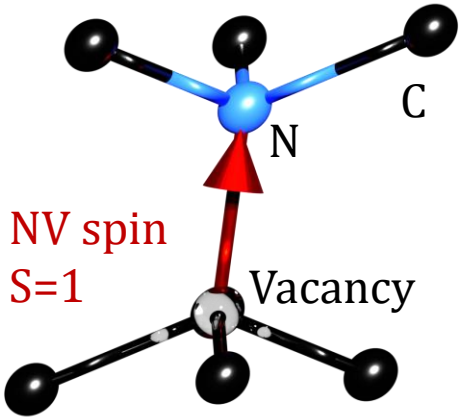




Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond

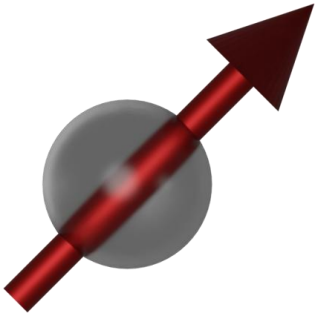


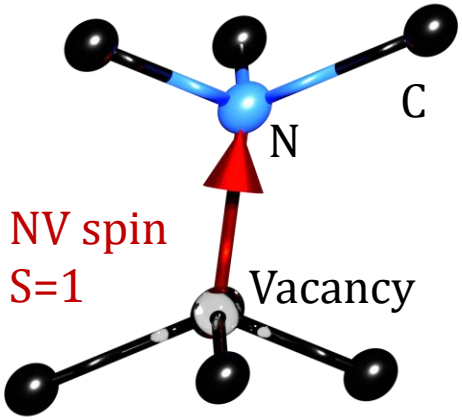


Optically Detected Magnetic Resonance (ODMR)

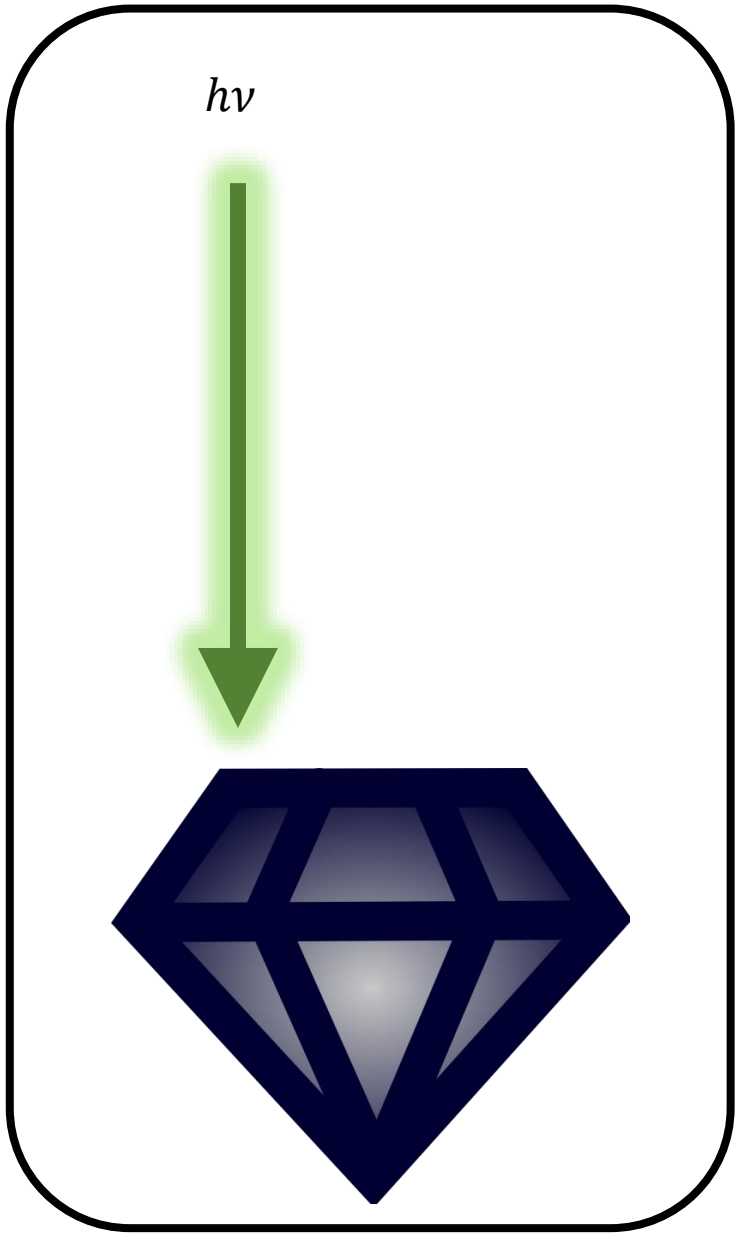
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond



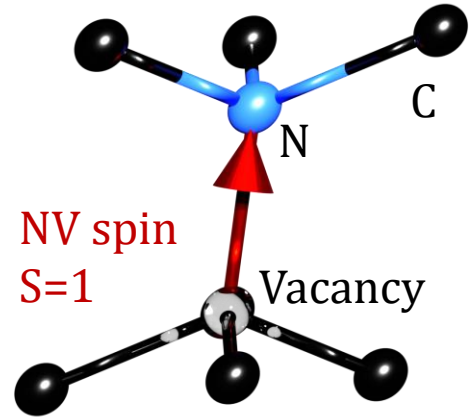


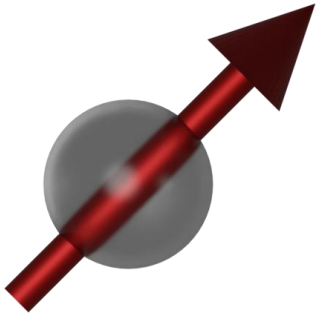
Optically Detected Magnetic Resonance (ODMR)



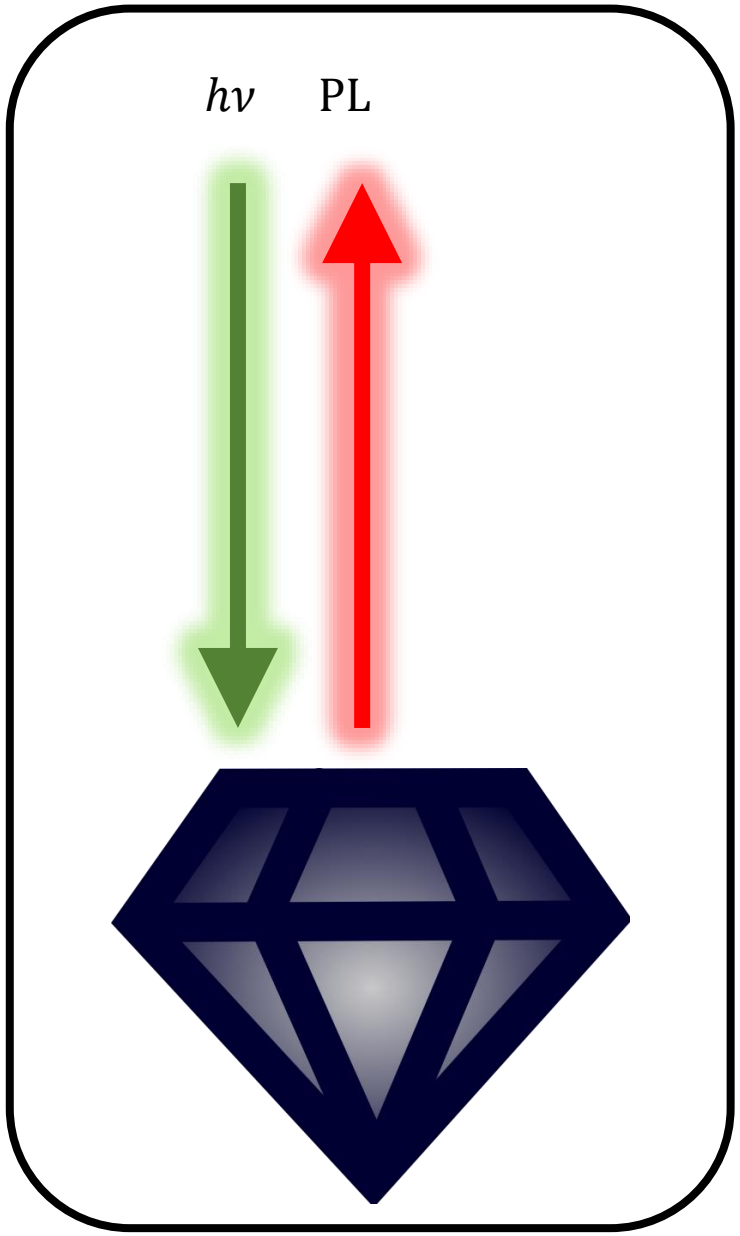
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond



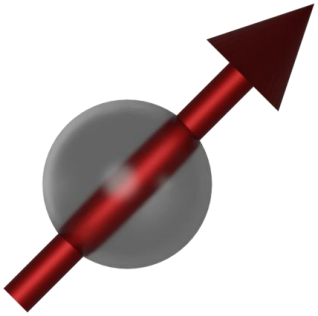


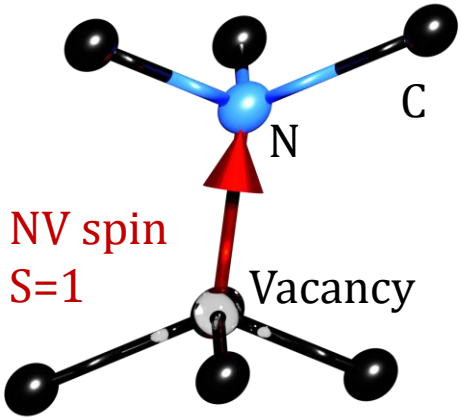
Optically Detected Magnetic Resonance (ODMR)



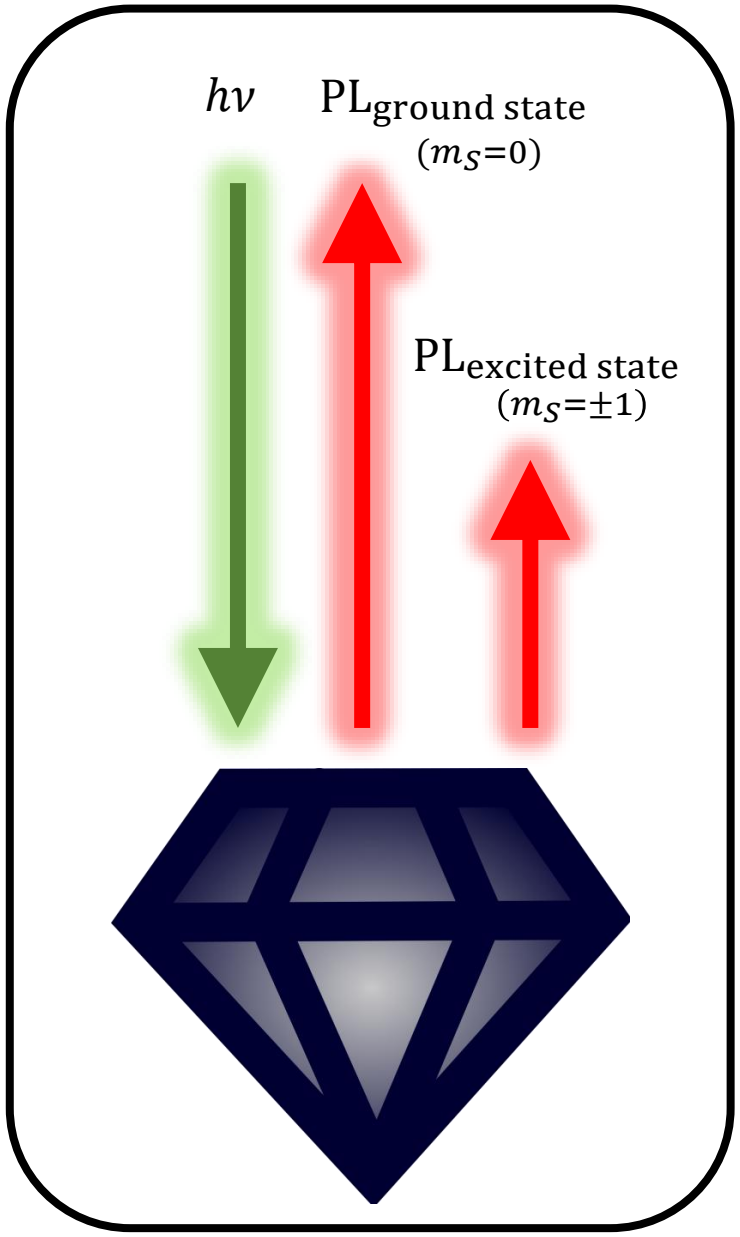
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond

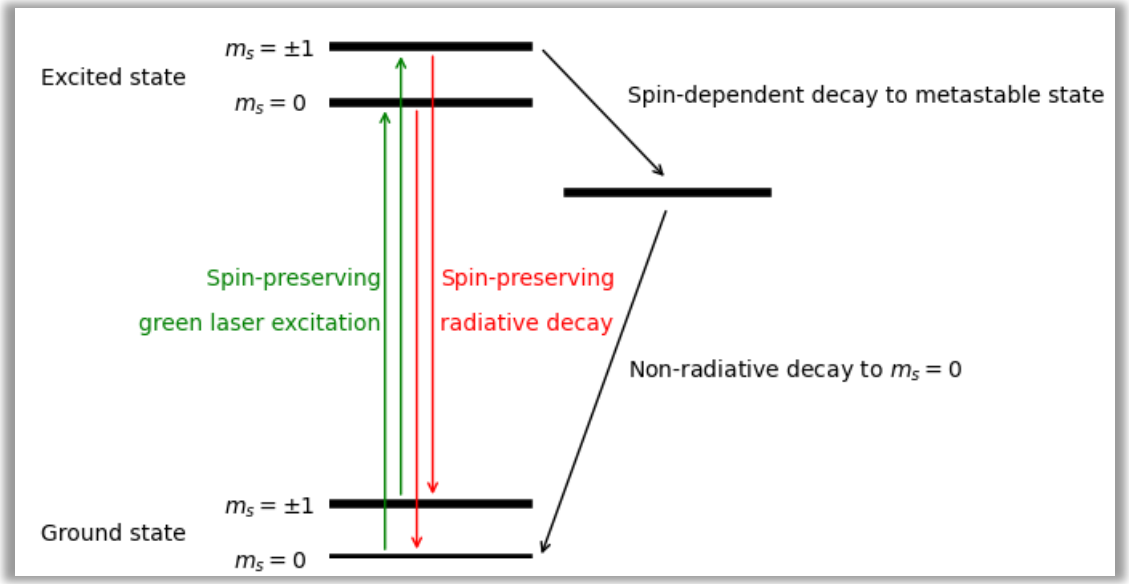


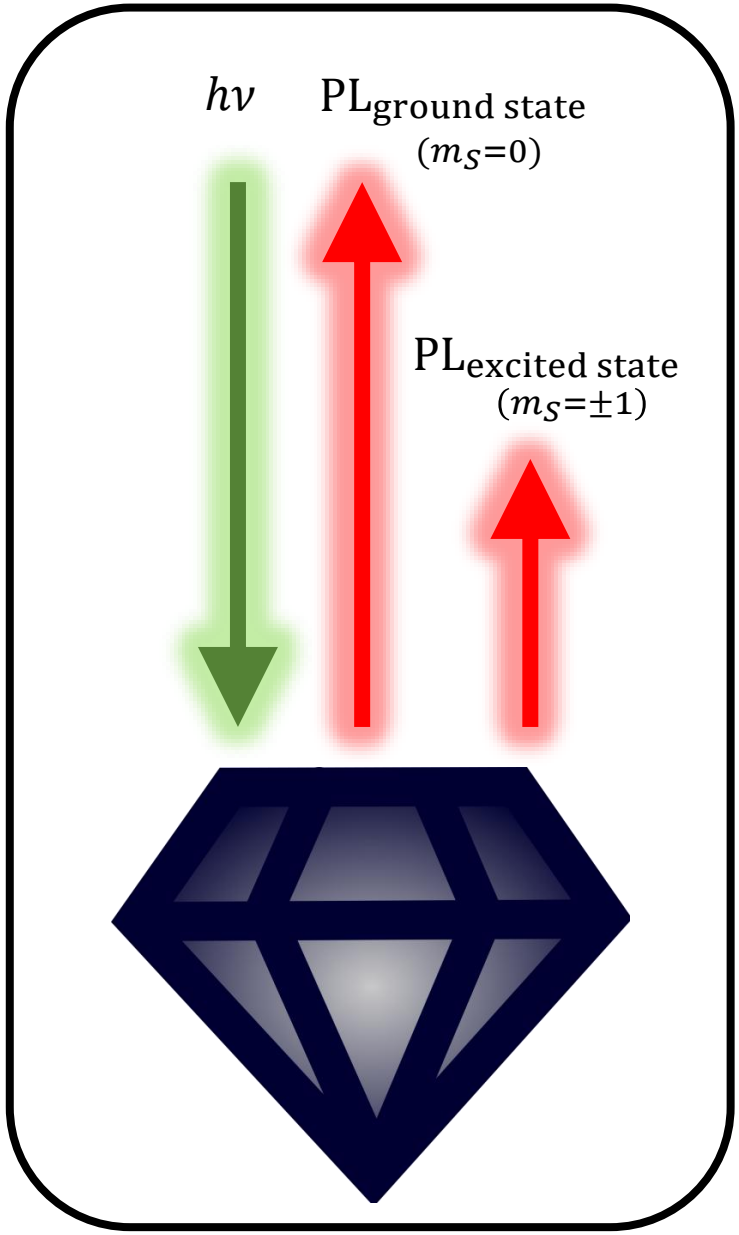


Optically Detected Magnetic Resonance (ODMR)



Quantum sensing with color centers



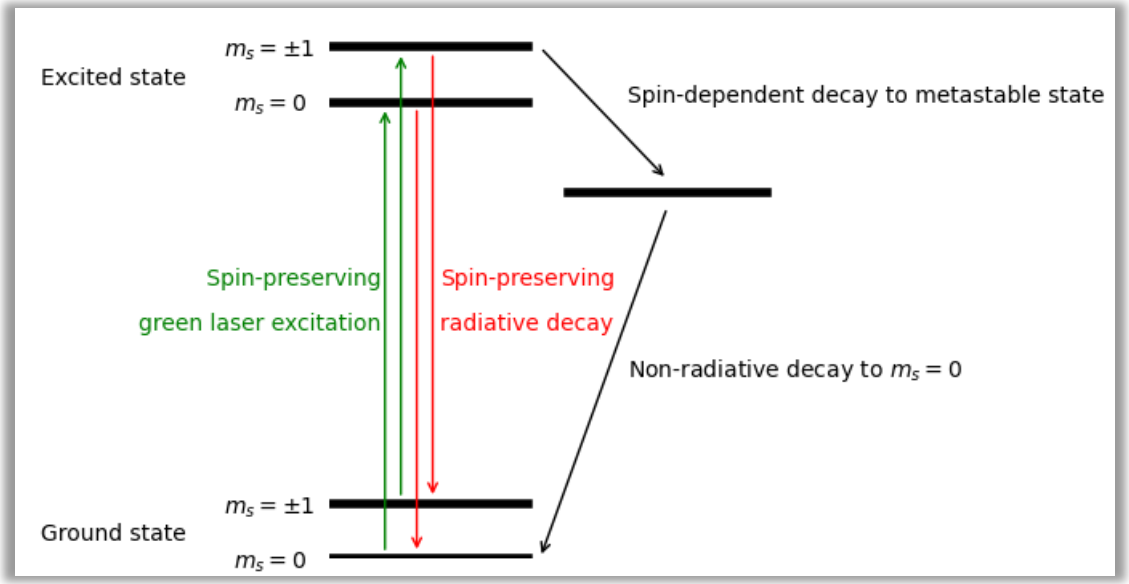


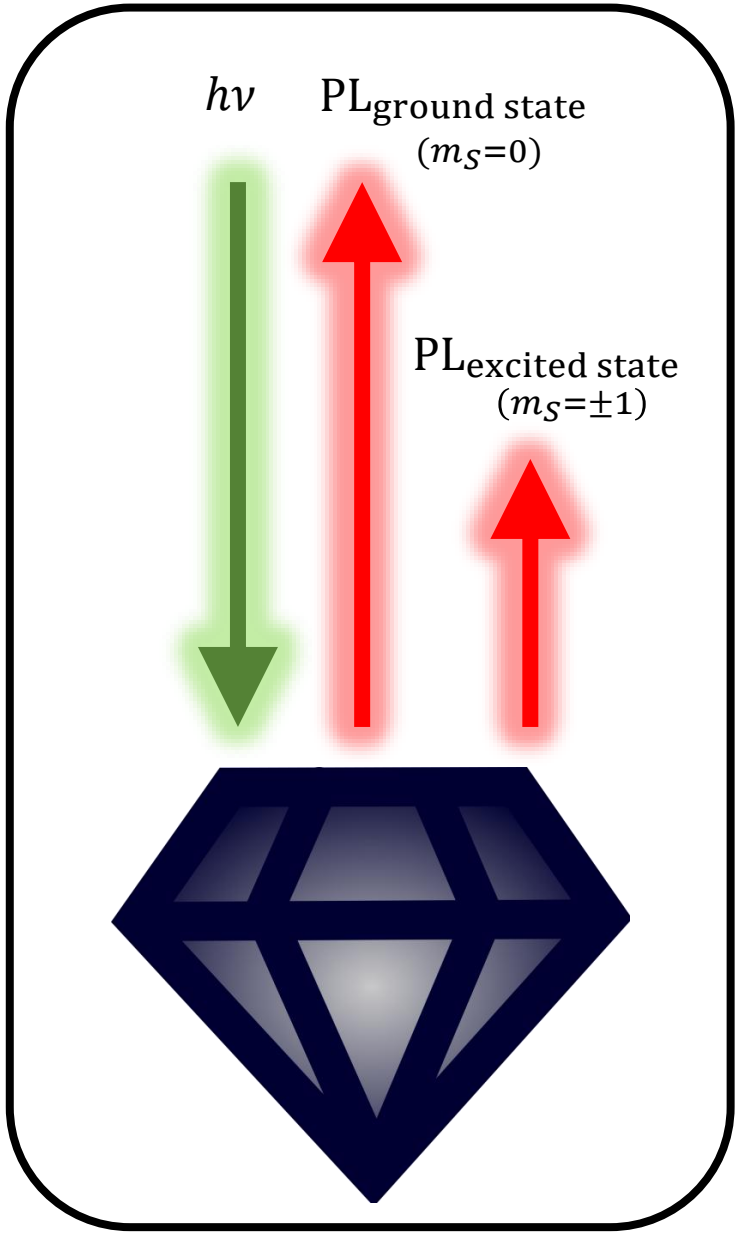
Optically Detected Magnetic Resonance (ODMR)

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

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

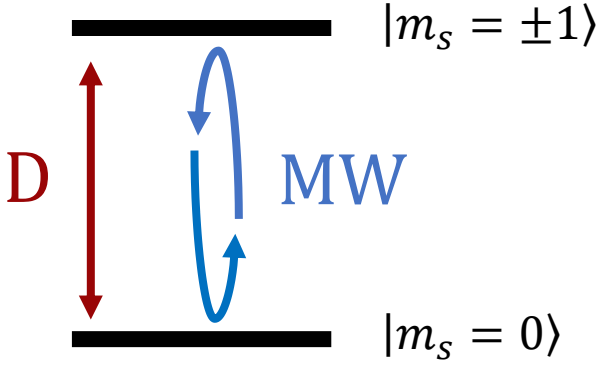
Quantum sensing with color centers





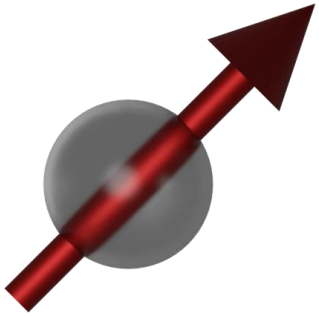
Optically Detected Magnetic Resonance (ODMR)

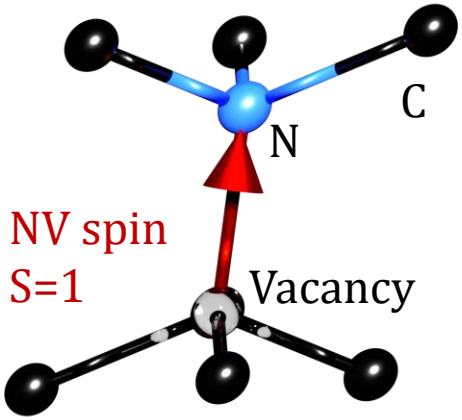
We can drive the NV between $|m_s = 0\rangle$ and $|m_s = \pm 1\rangle$ with microwave pulses!



Quantum sensing with color centers

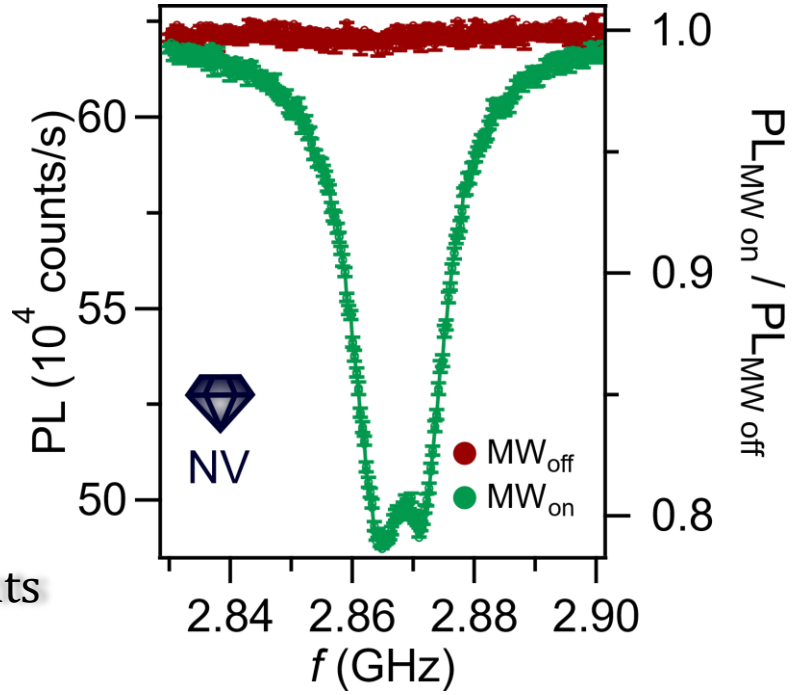
Nitrogen-Vacancy (NV) center in diamond





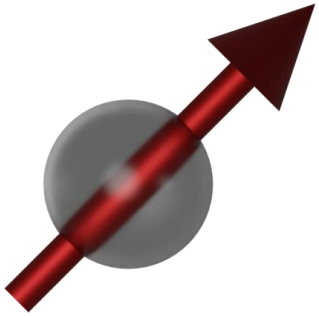
Optically Detected Magnetic Resonance (ODMR)

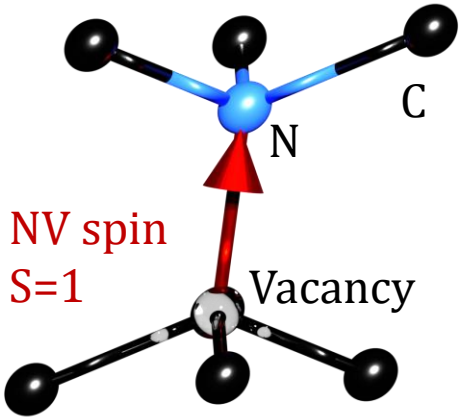
Zero-Field measurements



Quantum sensing with color centers

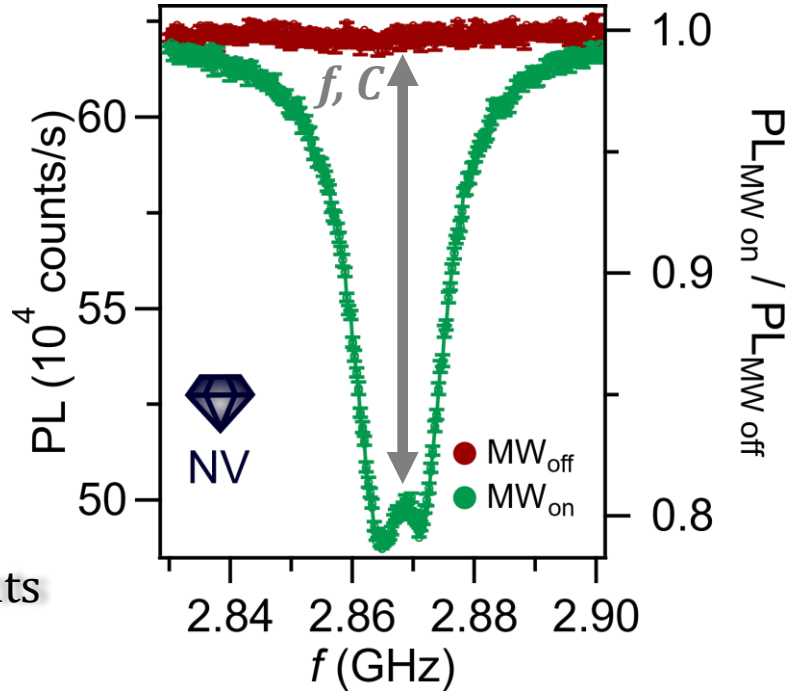
Nitrogen-Vacancy (NV) center in diamond



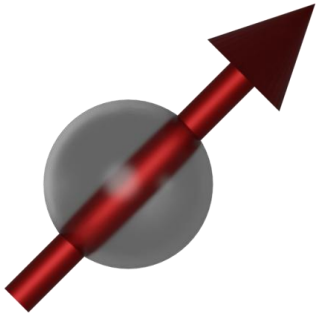


Optically Detected Magnetic Resonance (ODMR)

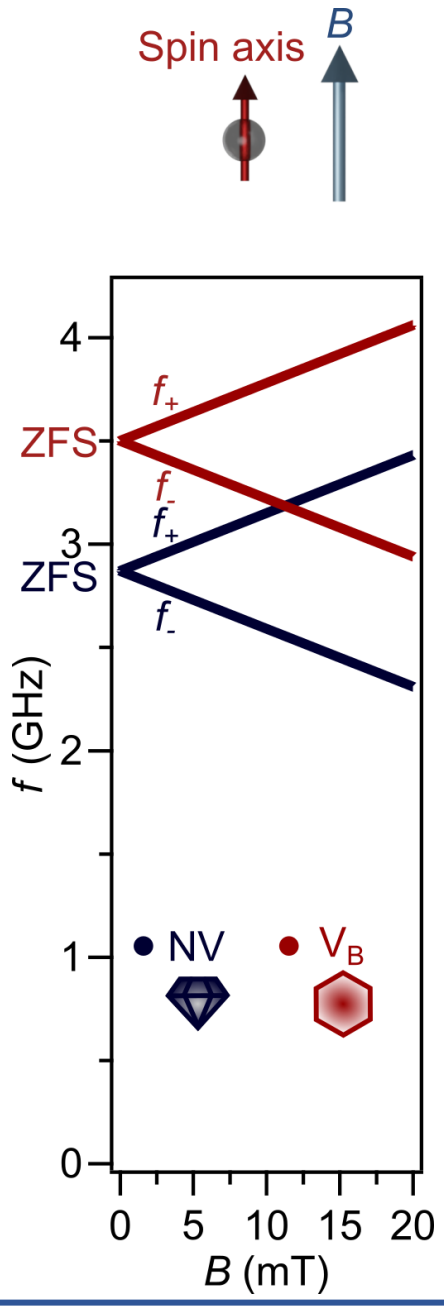
Zero-Field measurements



Quantum sensing with color centers



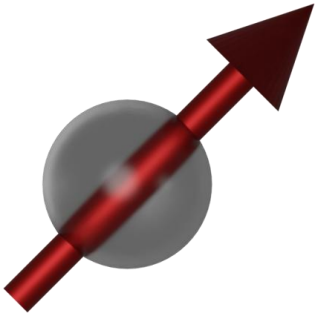
Magnetometry

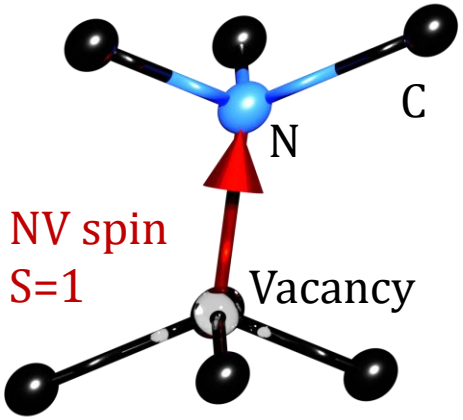


Why *colors*?

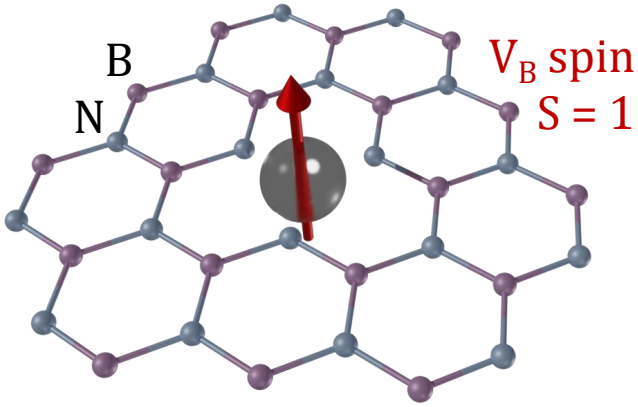
Quantum sensing with color centers

Nitrogen-Vacancy (NV) center in diamond



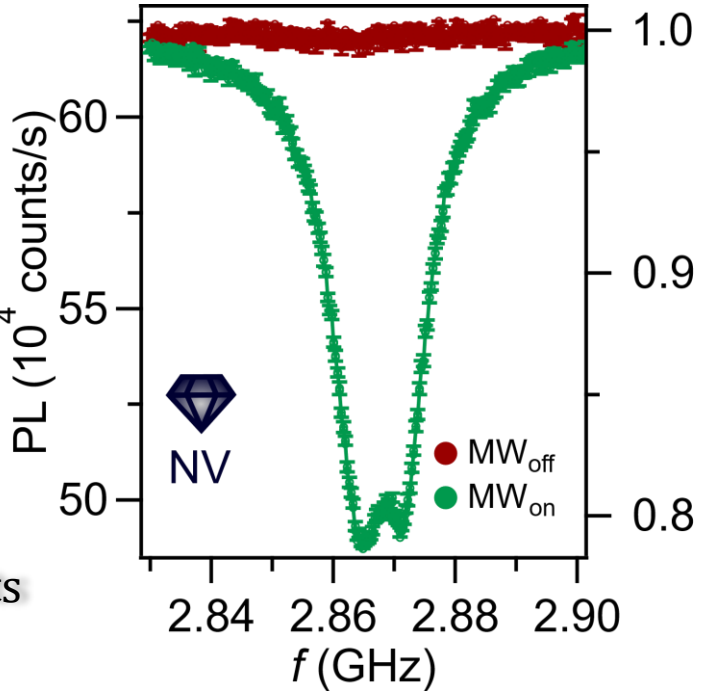


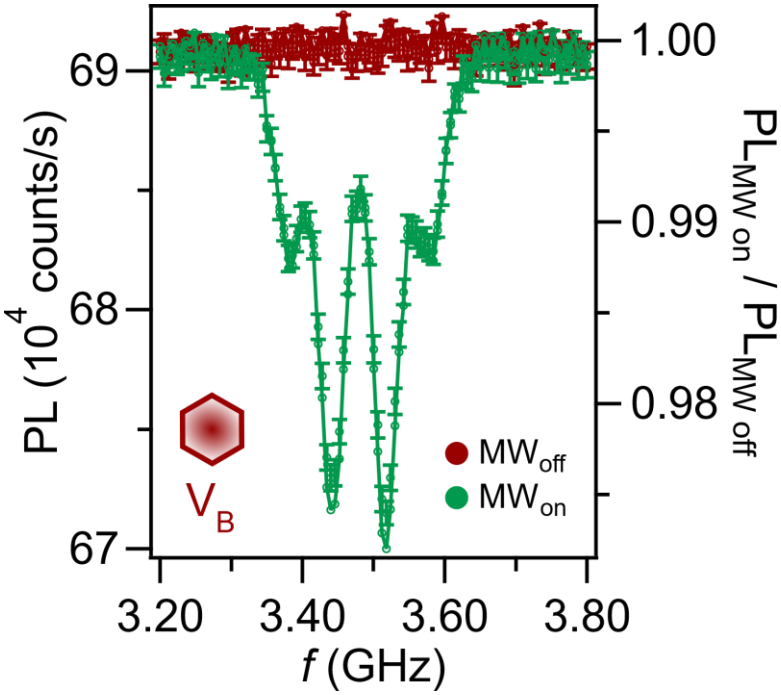
Boron Vacancy in hBN (van der Waals material)



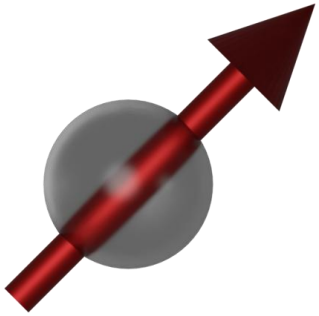
Optically Detected Magnetic Resonance (ODMR)

Zero-Field measurements

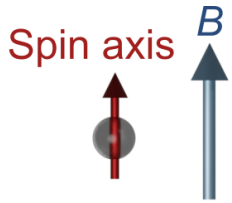


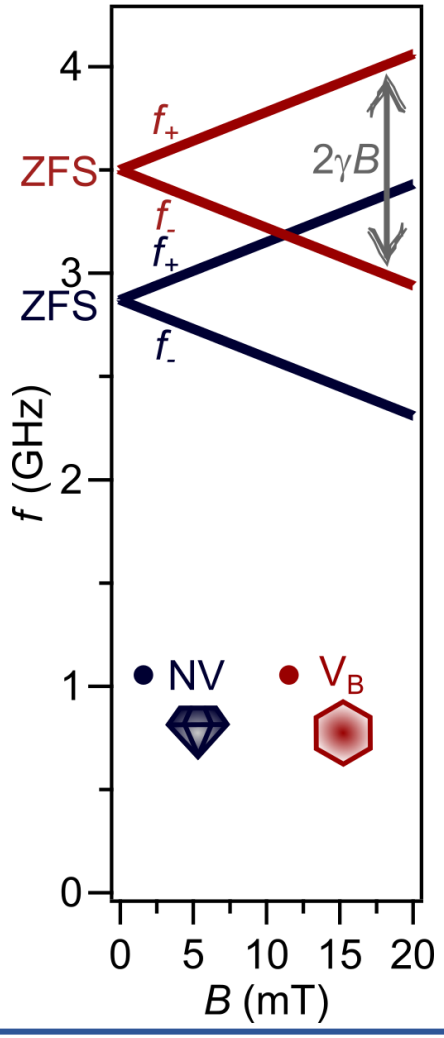


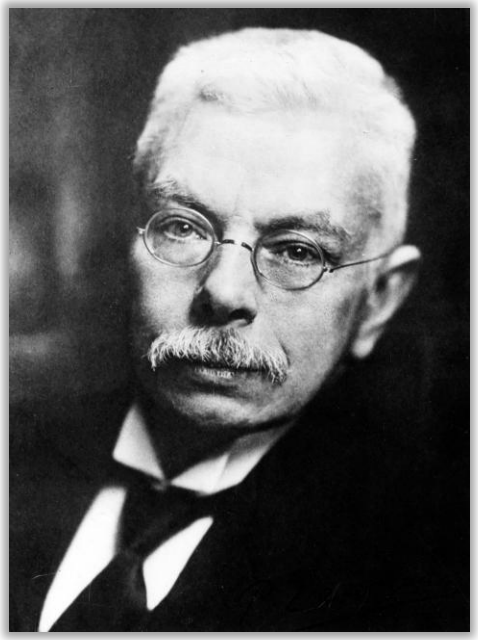
Color center magnetometry



Magnetometry

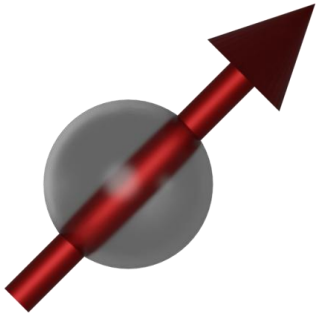


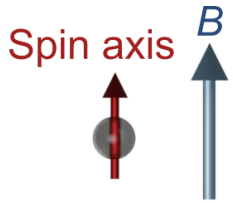




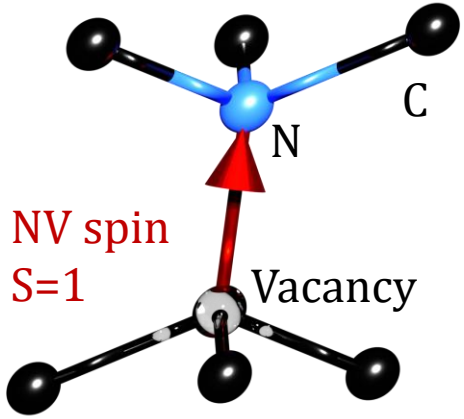
Pieter Zeeman
(1865-1943)

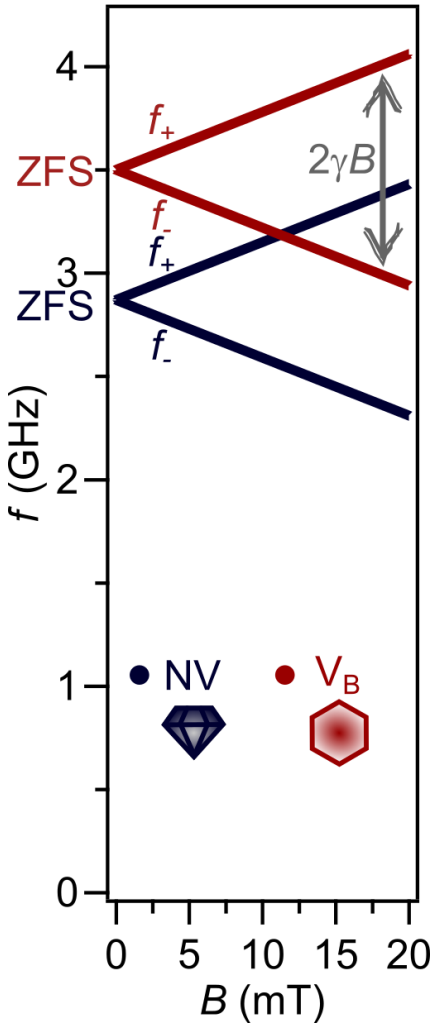
Color center magnetometry



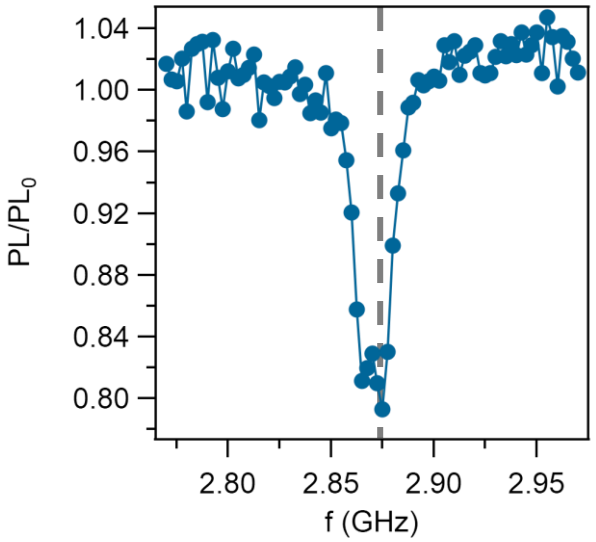


Nitrogen-Vacancy (NV) center in diamond

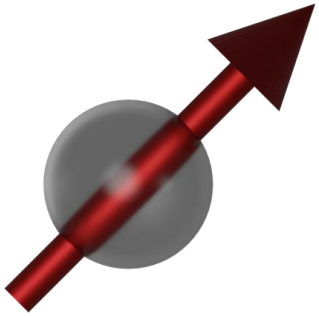




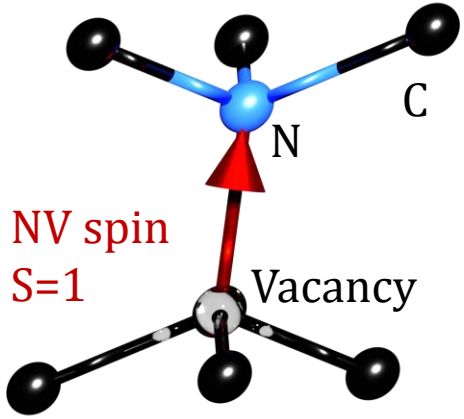
B = 0

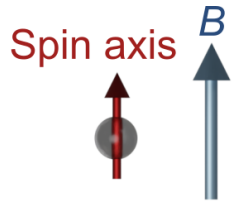


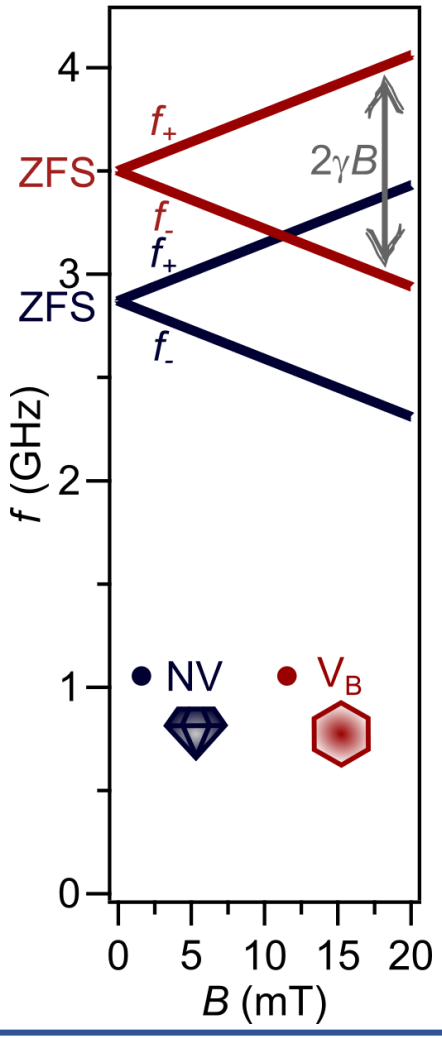
Color center magnetometry



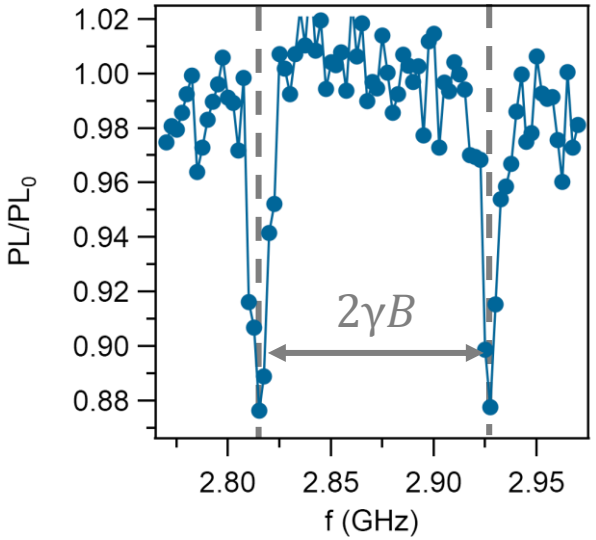
Nitrogen-Vacancy (NV) center in diamond



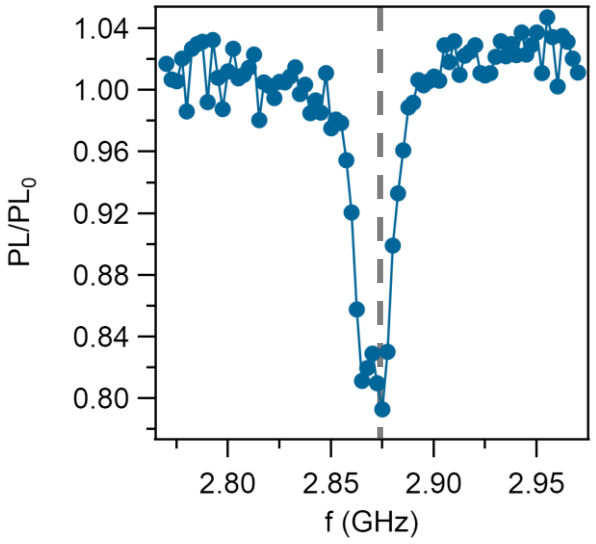




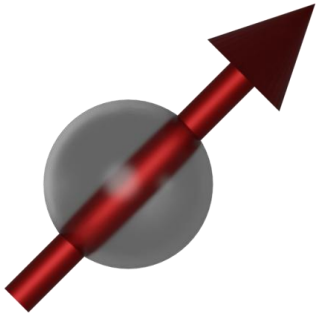
$B \neq 0$



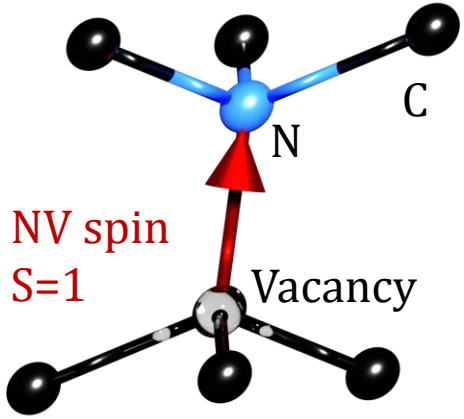
$B = 0$

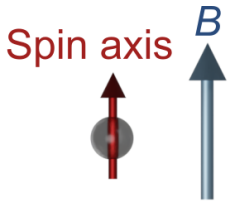


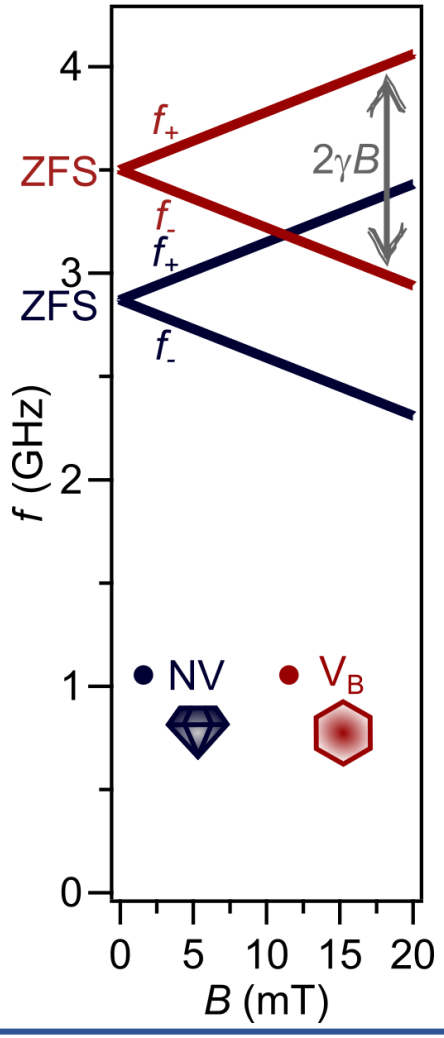
Color center magnetometry



Nitrogen-Vacancy (NV) center in diamond

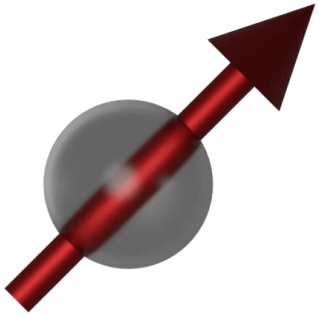




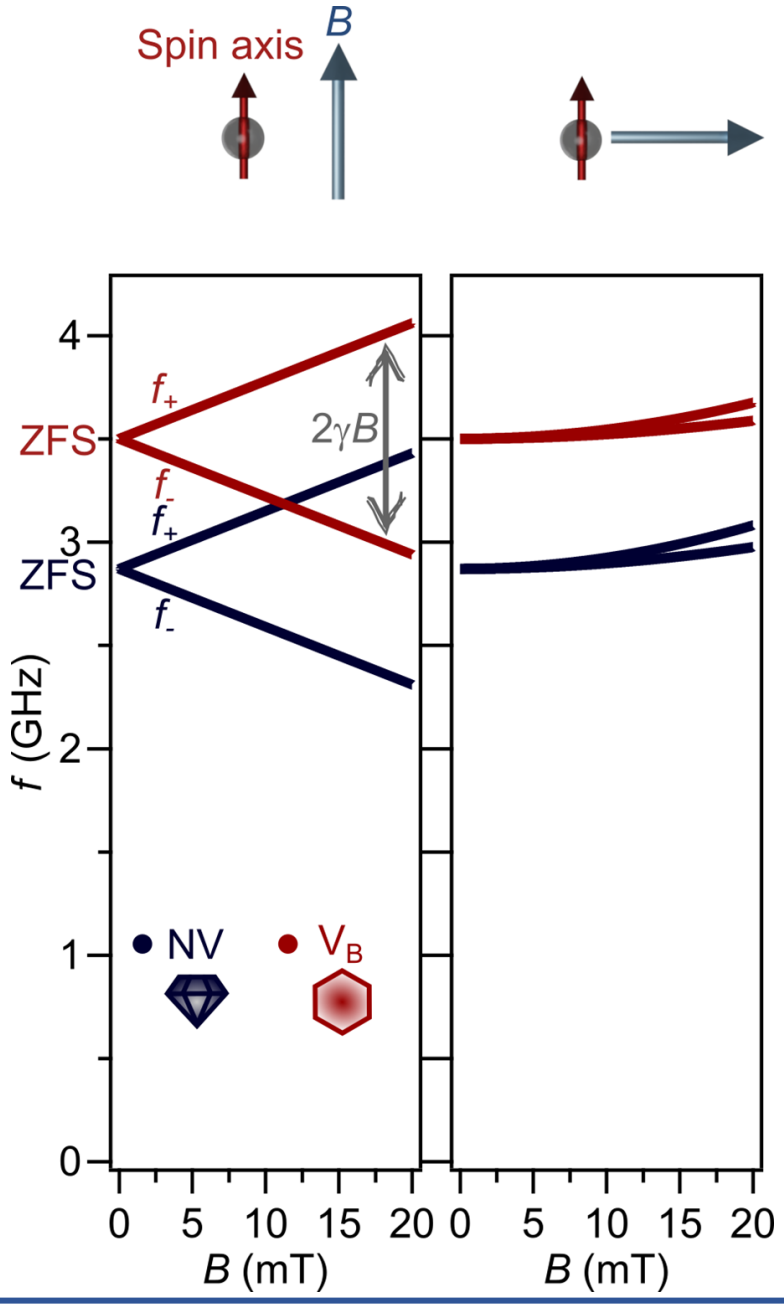


Resonance frequency depends on magnetic field

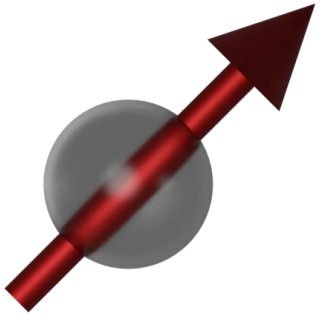
Color center magnetometry for spin-wave imaging



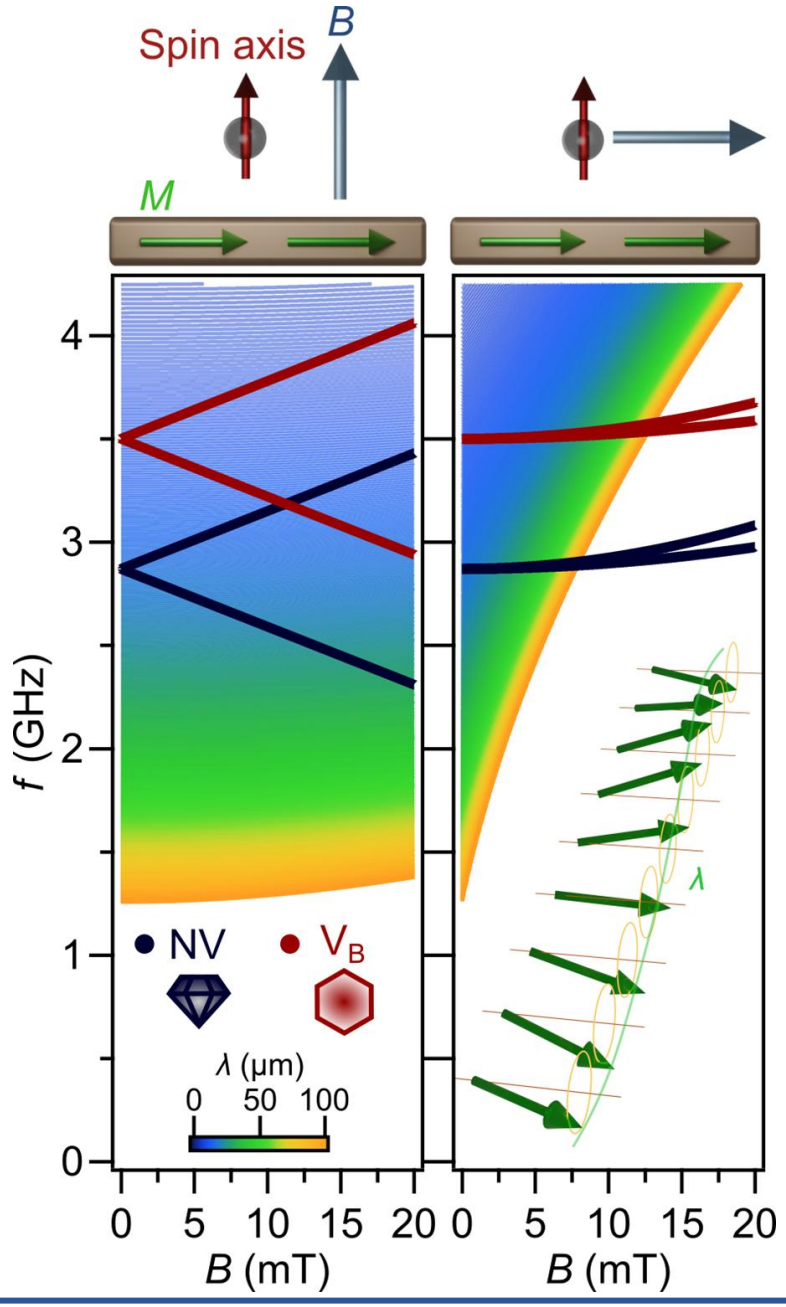
Isofrequency measurements



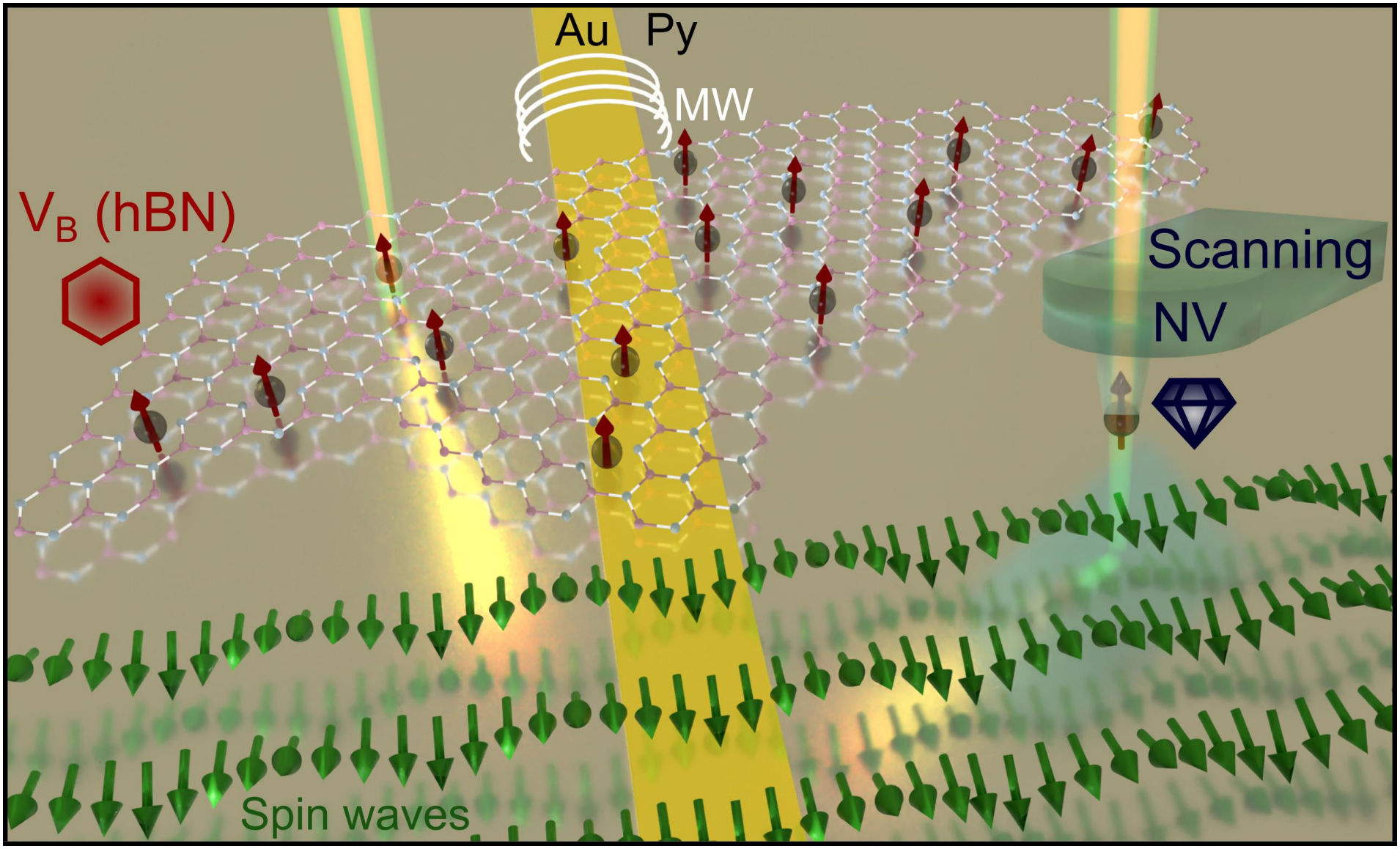
Color center magnetometry for spin-wave imaging



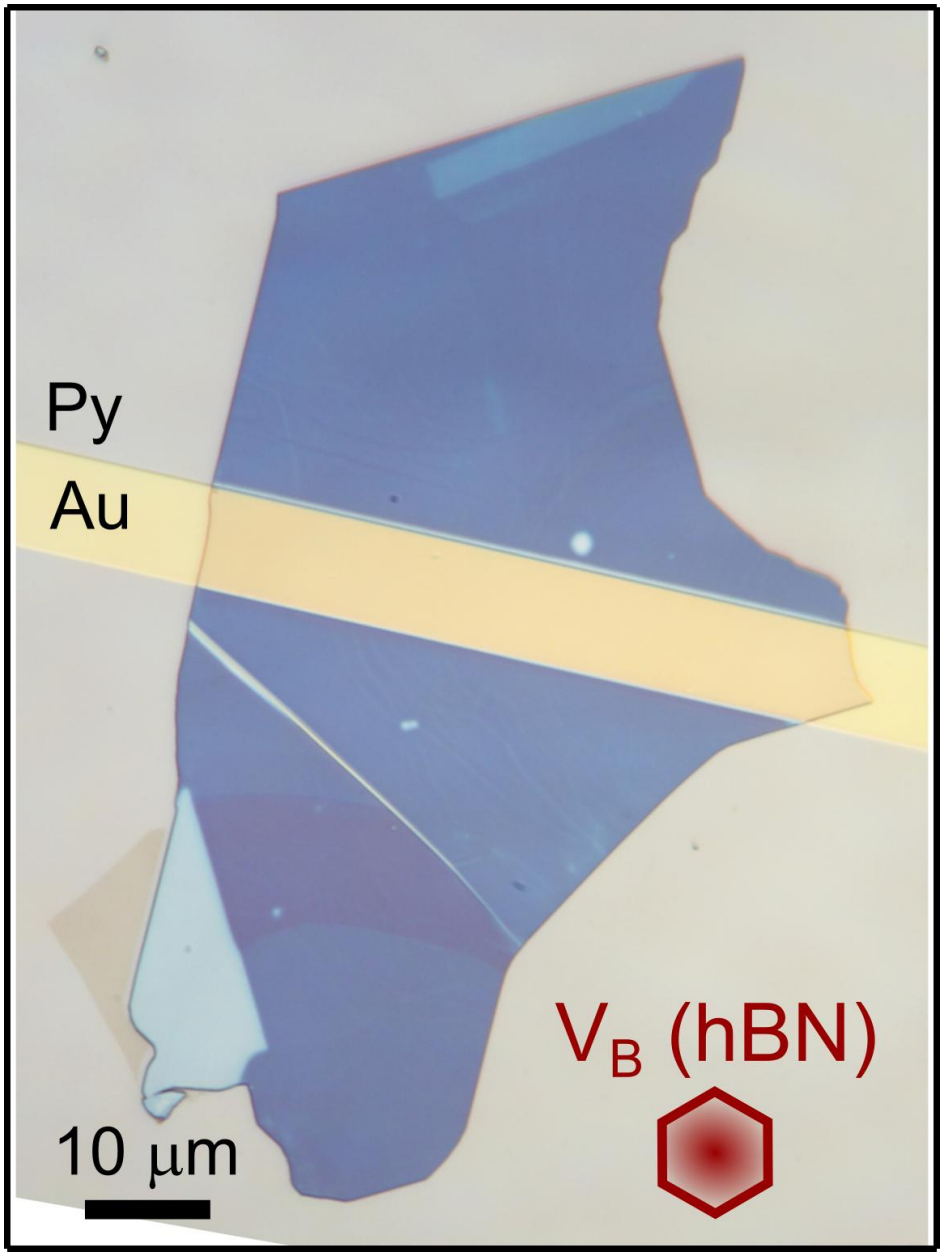
Isofrequency measurements



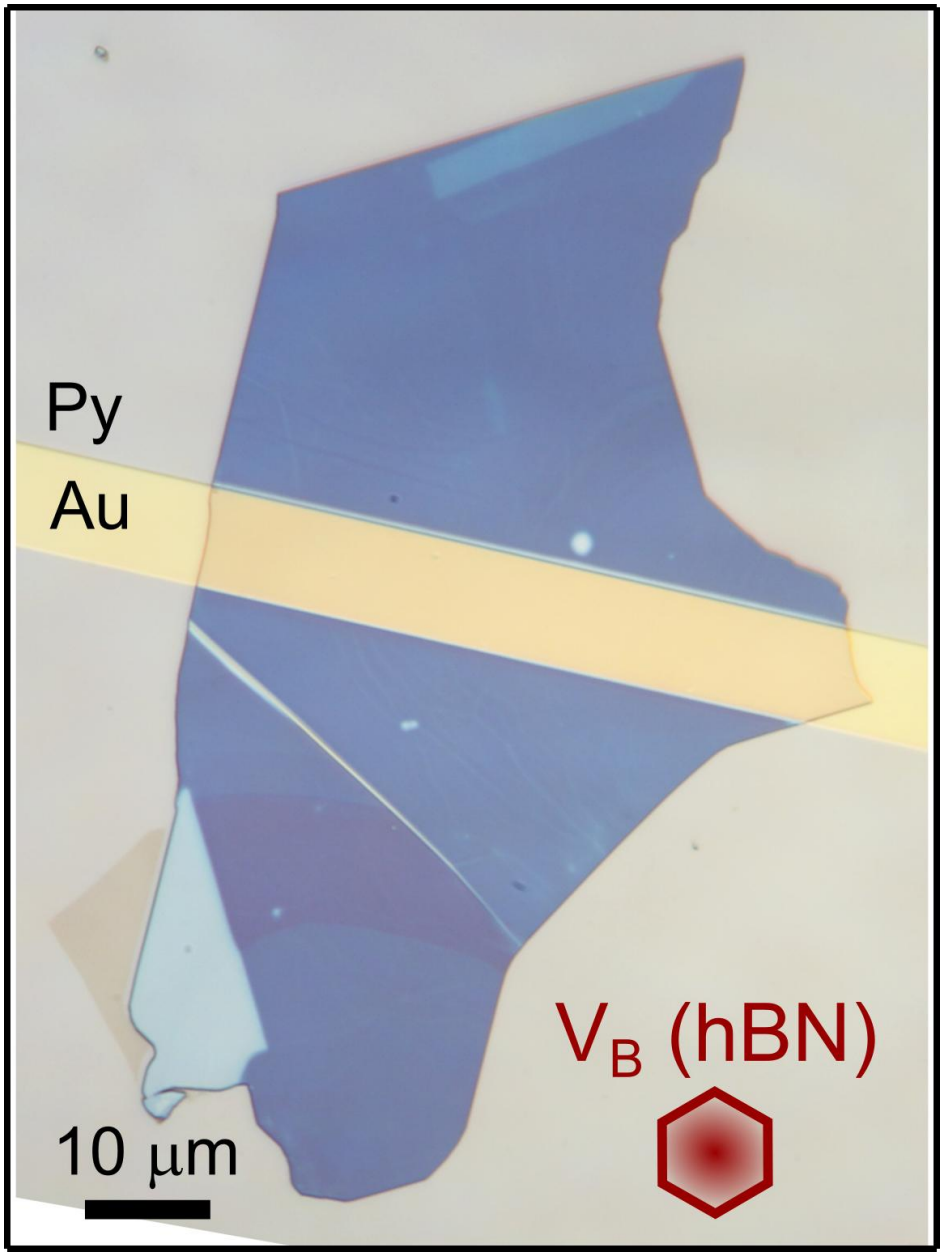
Color center magnetometry for spin-wave imaging

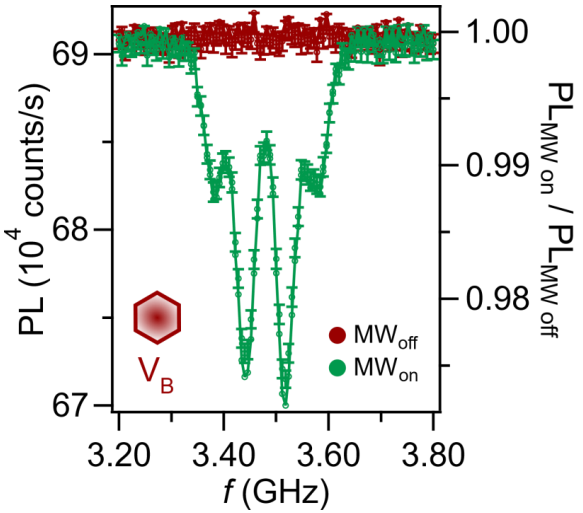


Color center magnetometry for spin-wave imaging

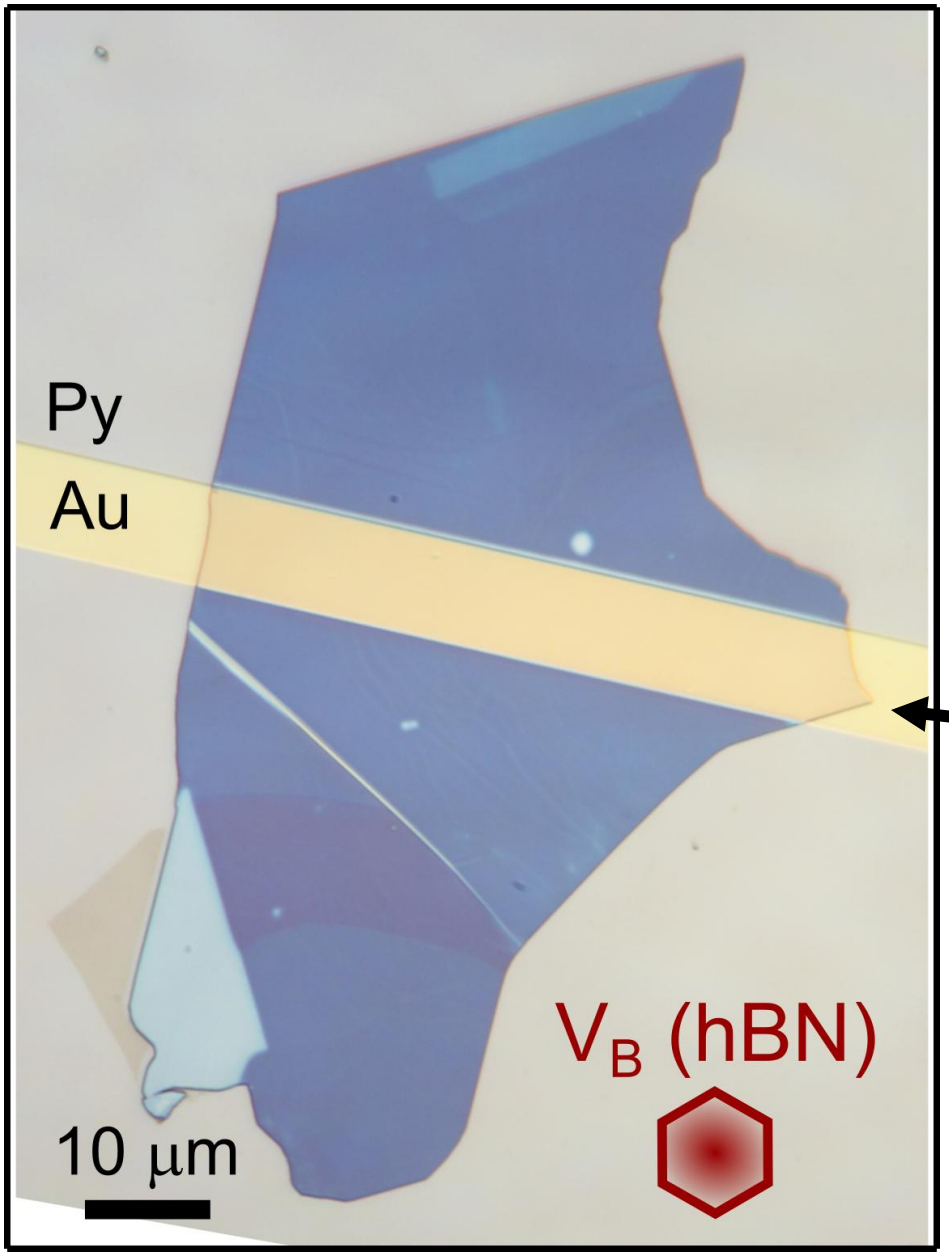


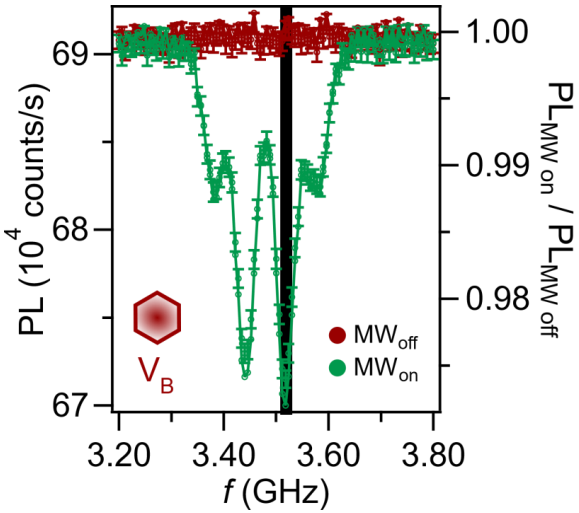
Color center magnetometry for spin-wave imaging



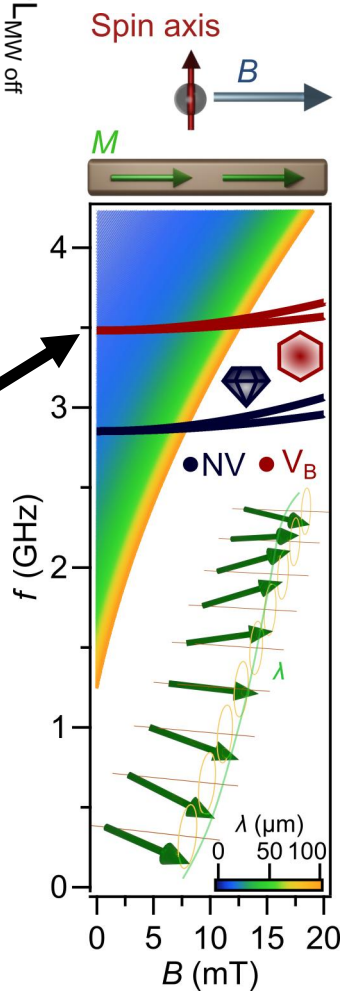


Color center magnetometry for spin-wave imaging

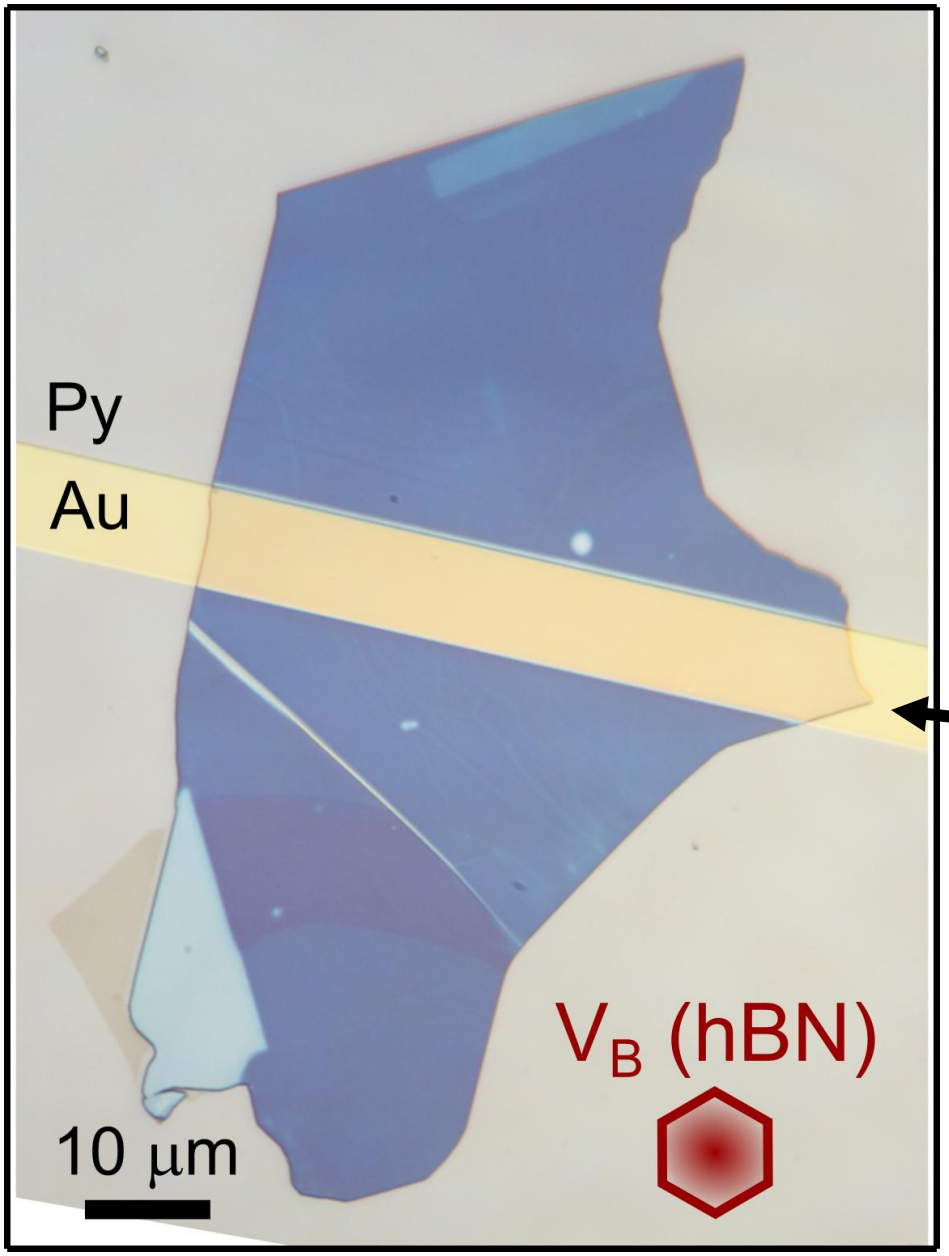


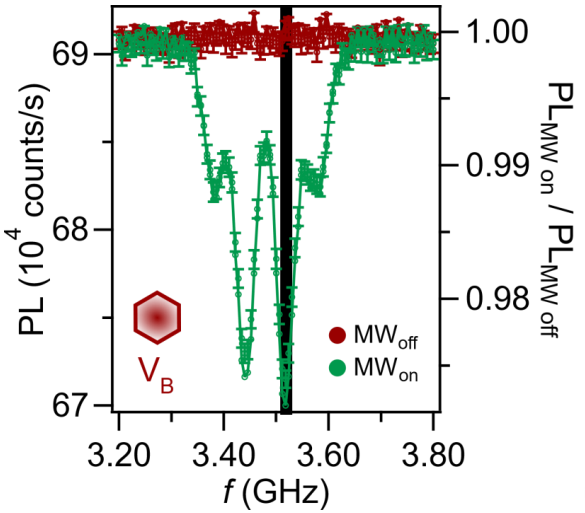


Microwave
f = 3.52 GHz

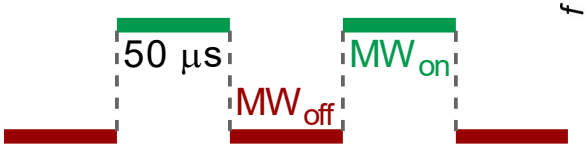


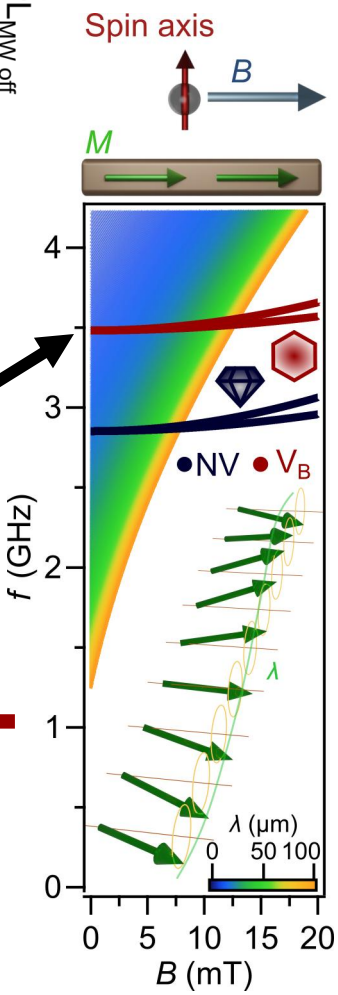
Color center magnetometry for spin-wave imaging



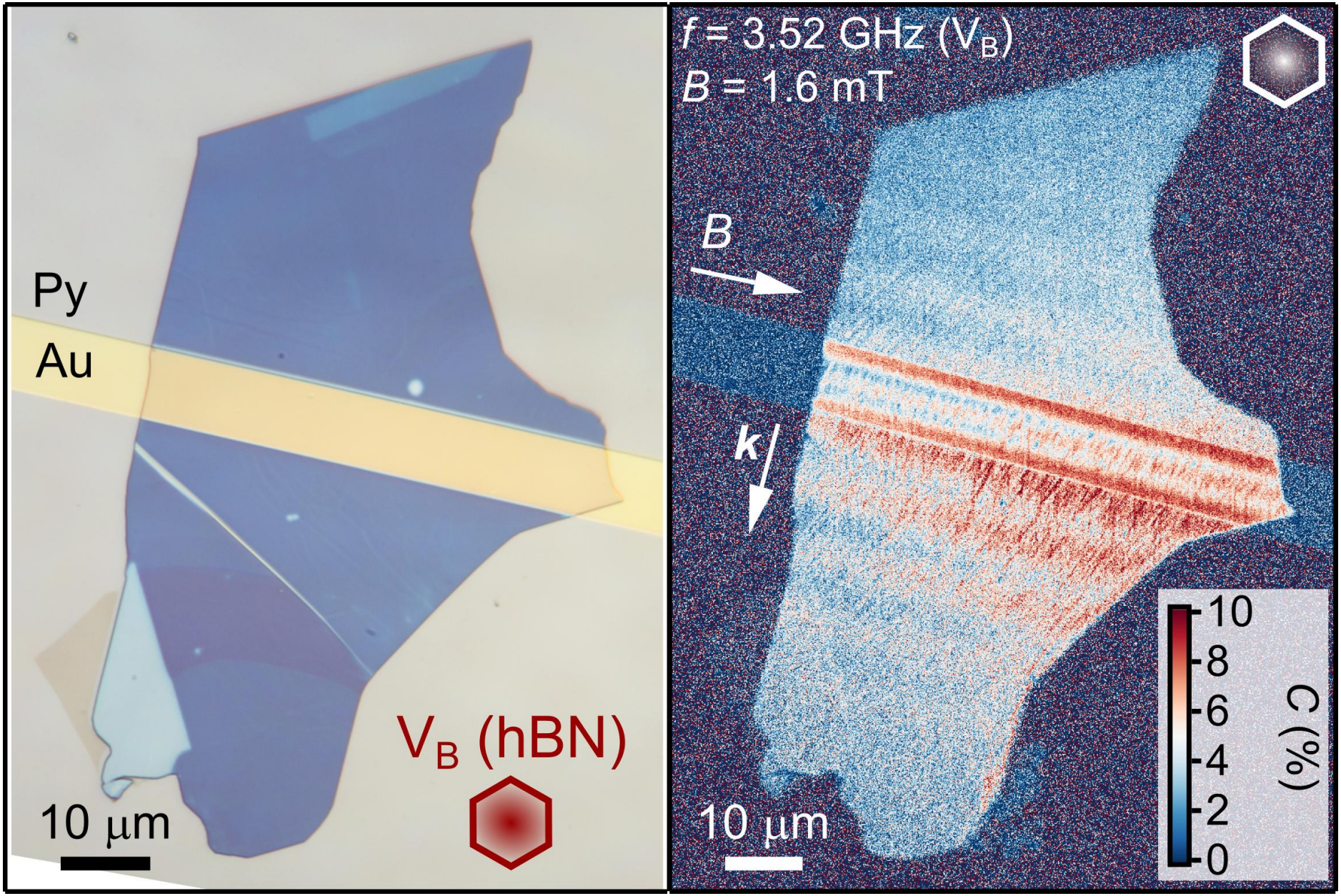


Microwave
f = 3.52 GHz

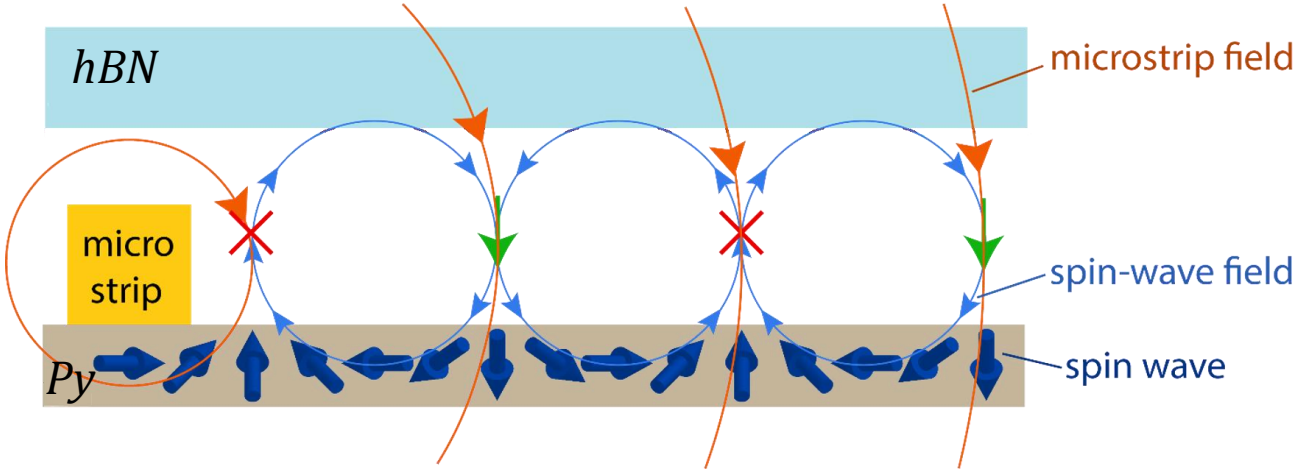


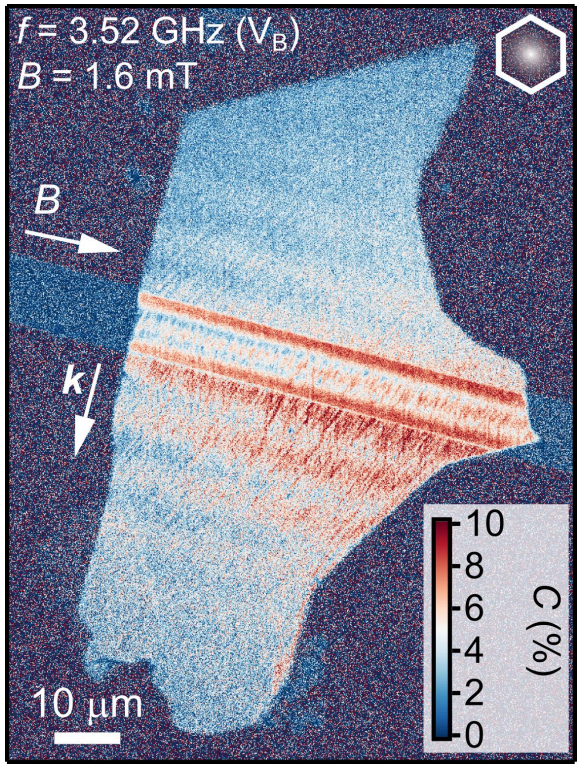


Color center magnetometry for spin-wave imaging

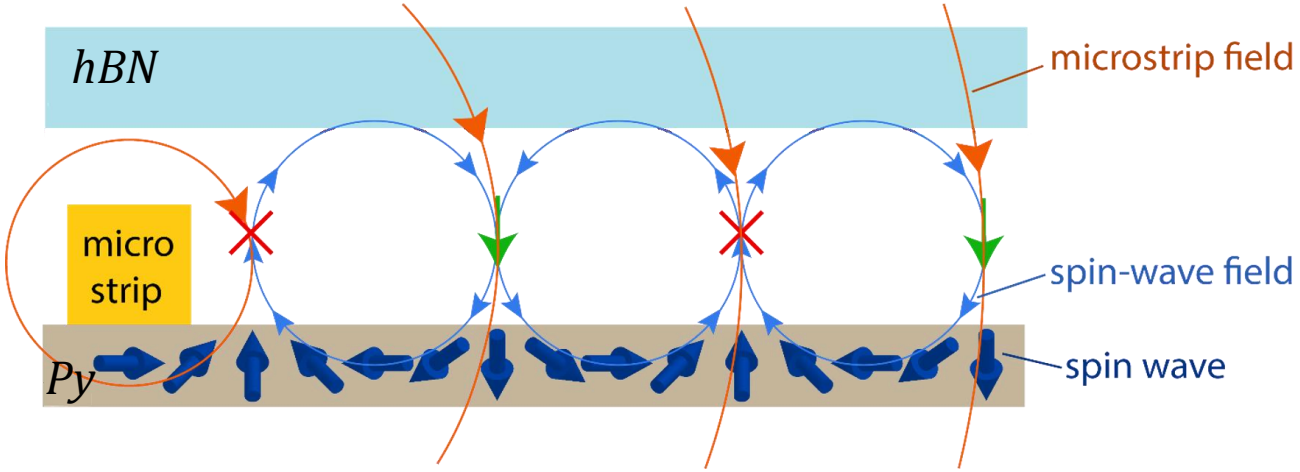


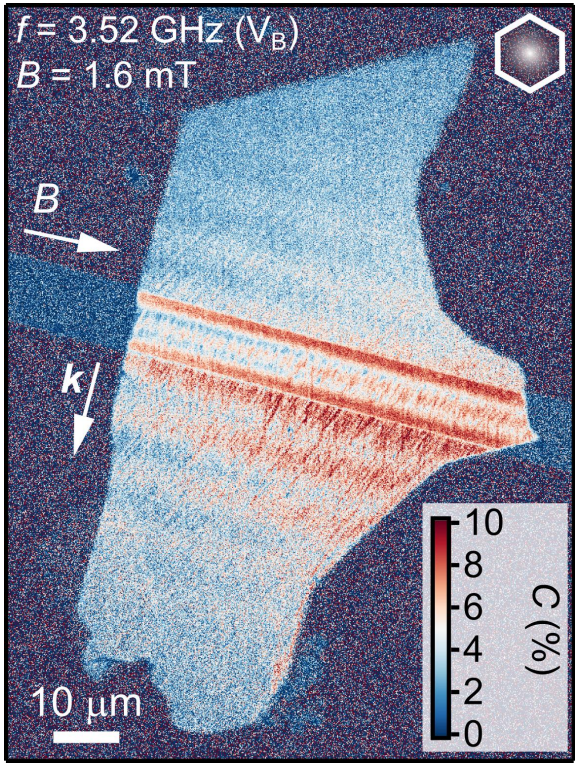
Why we see an interference pattern?

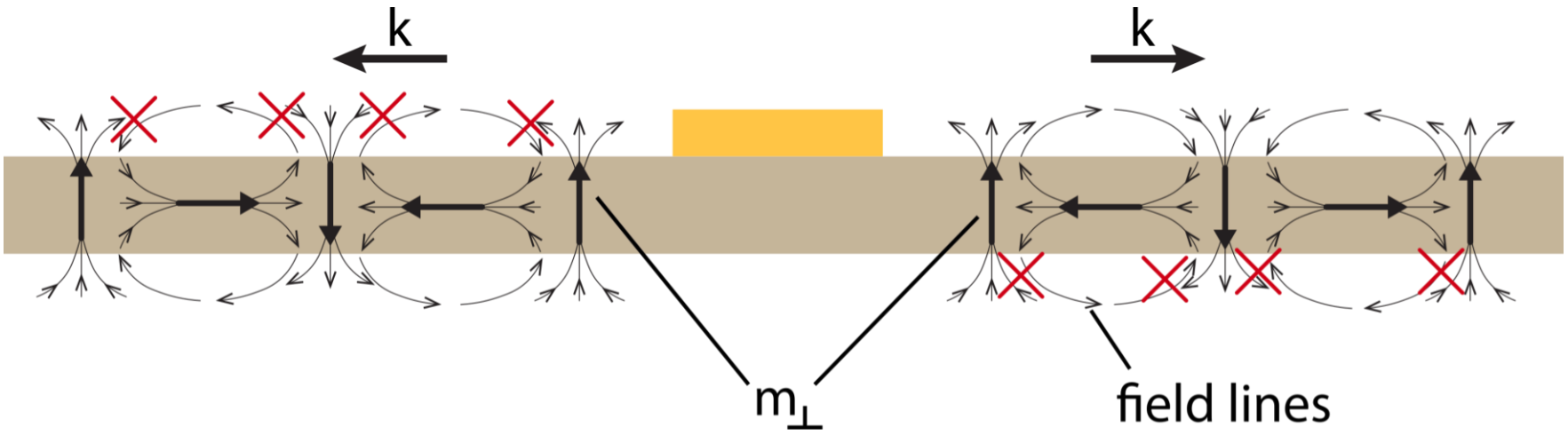




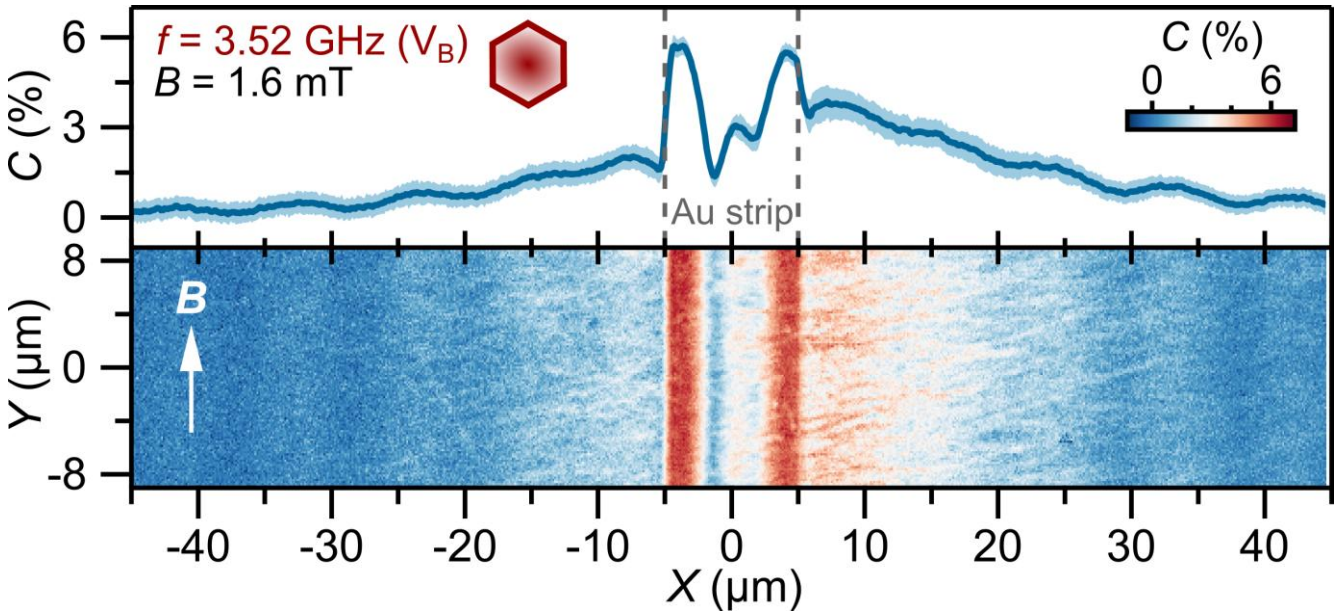
Non-reciprocity

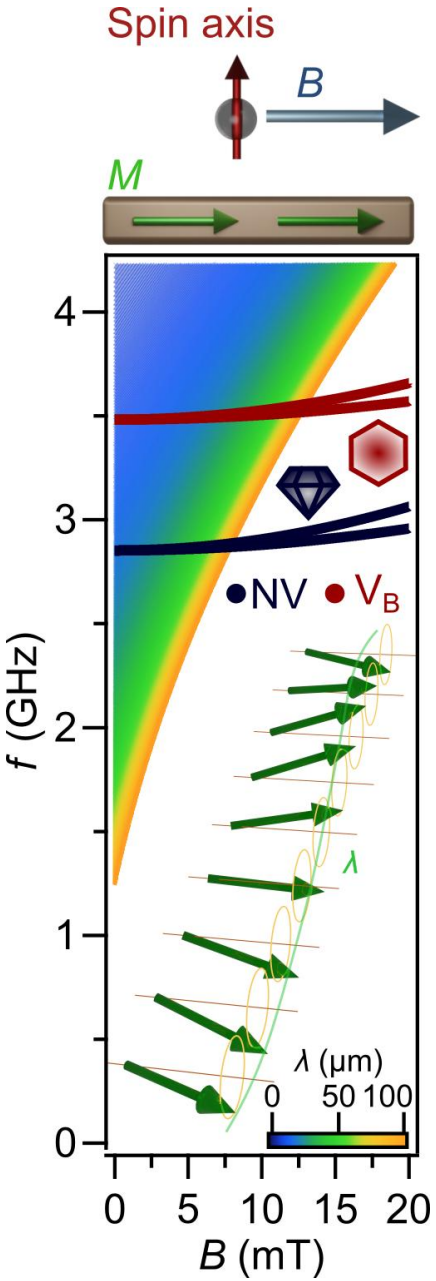




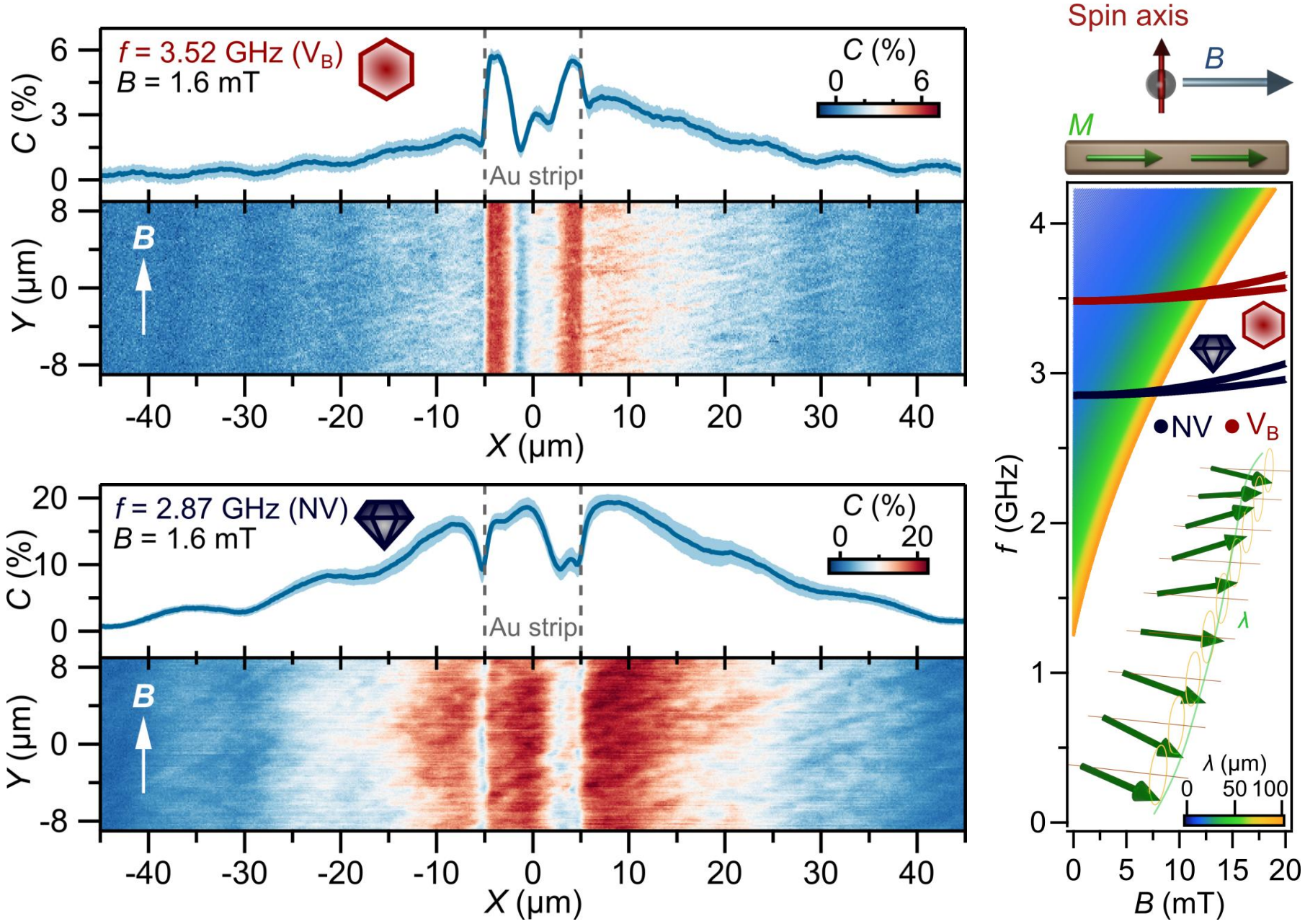


Isofrequency spin-wave imaging

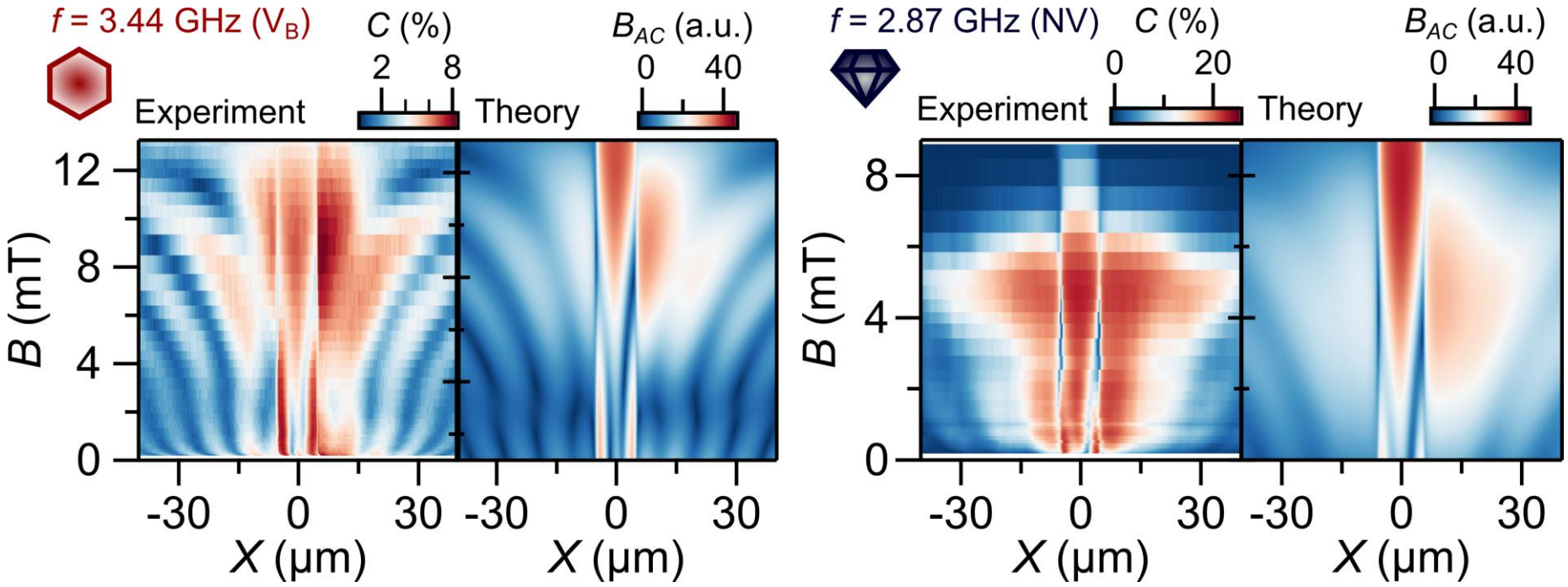




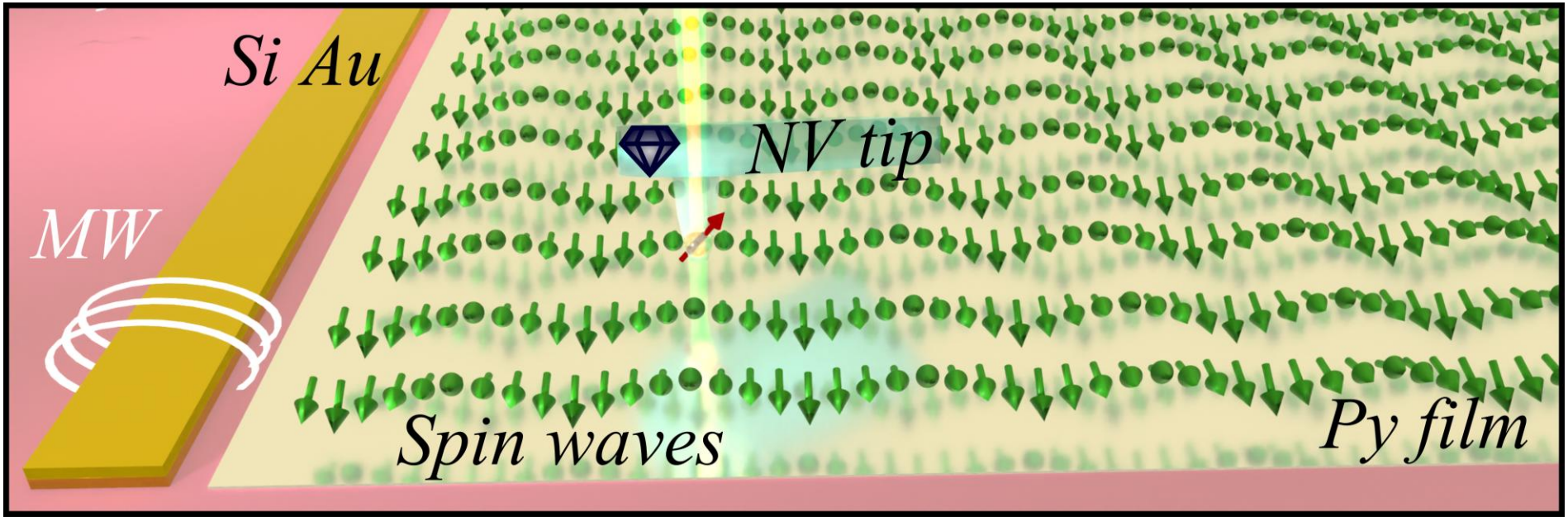
Isofrequency spin-wave imaging



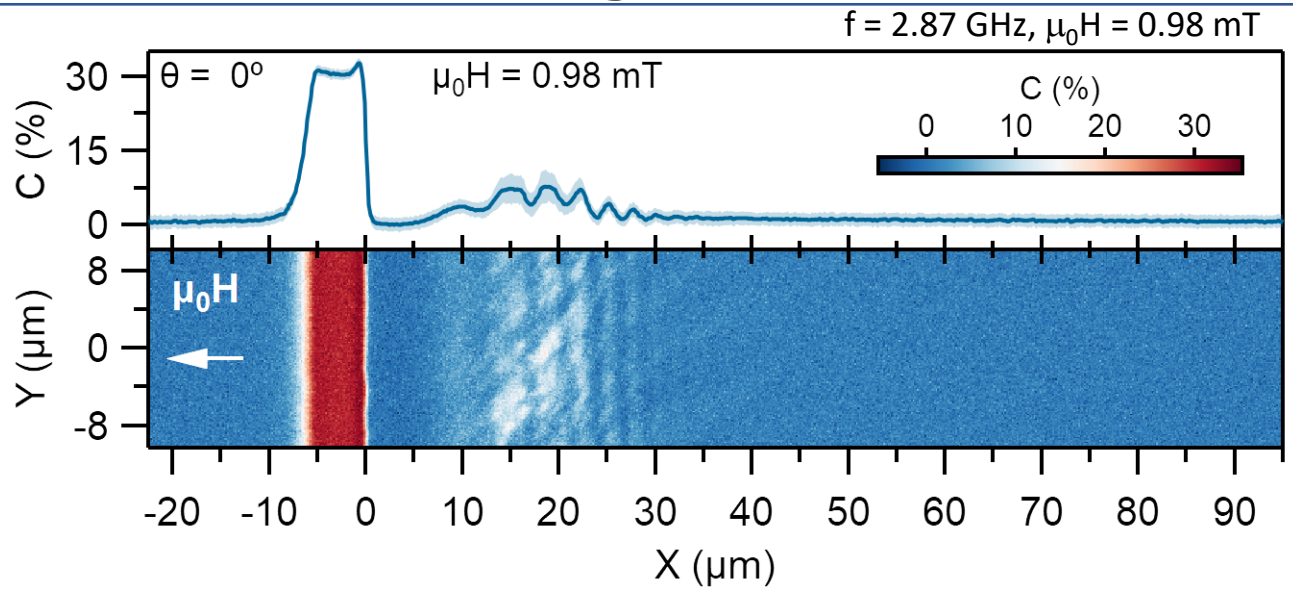
Isofrequency spin-wave imaging

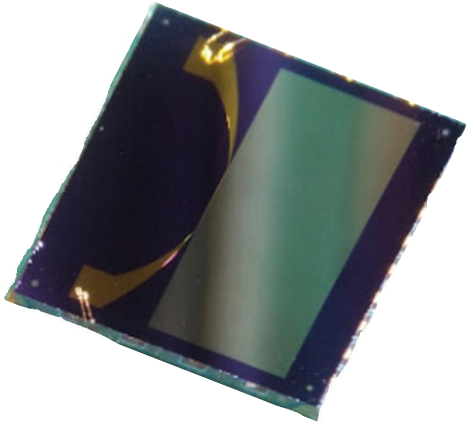


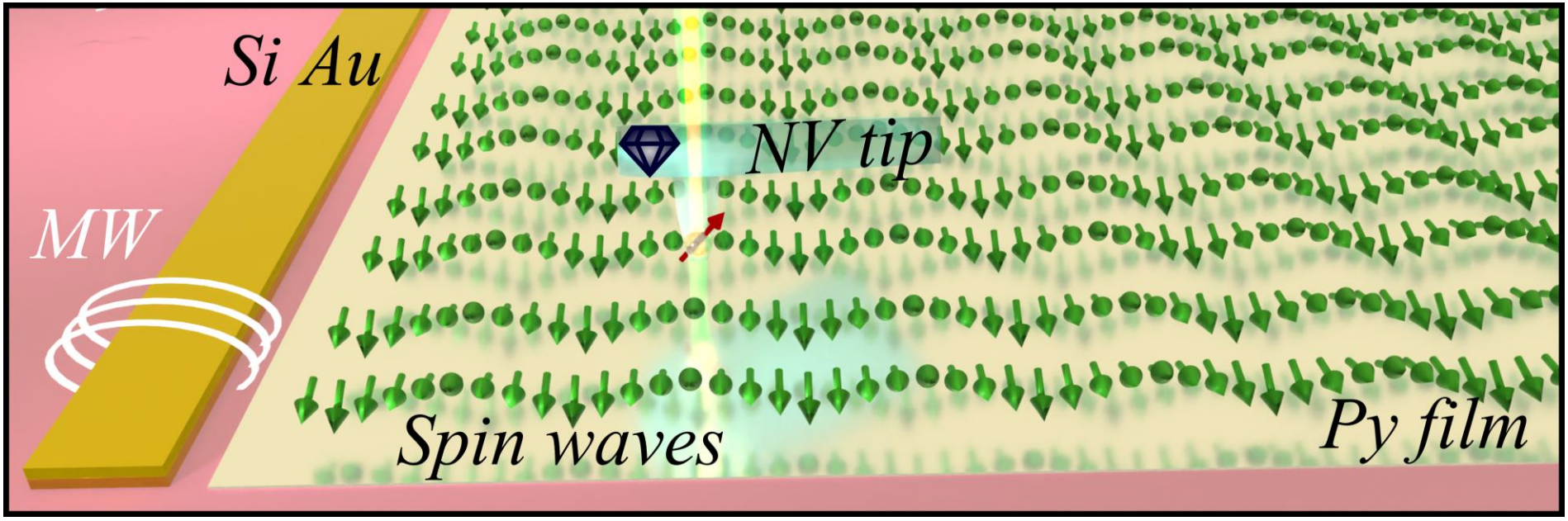
Magnons at the beach



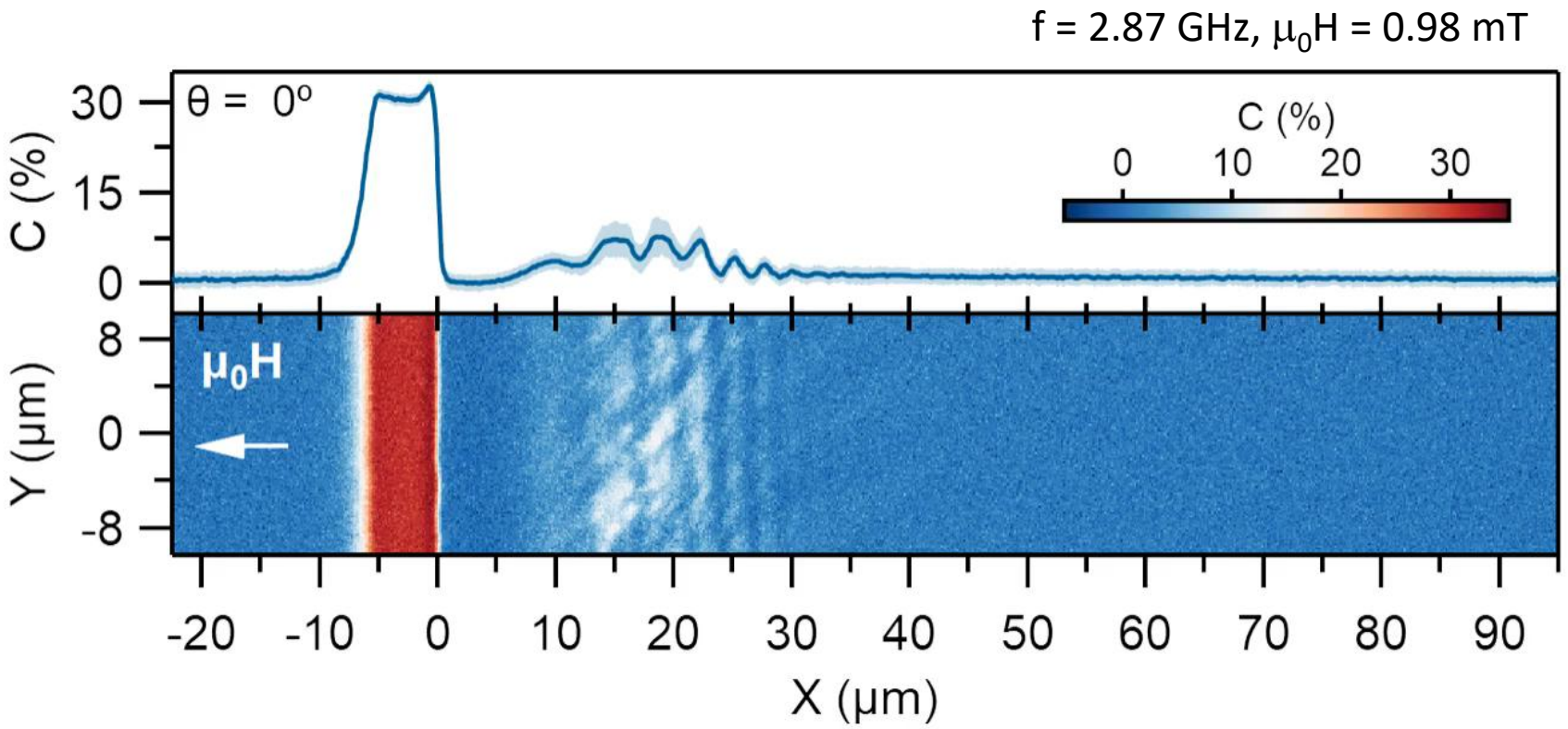
Magnons at the beach





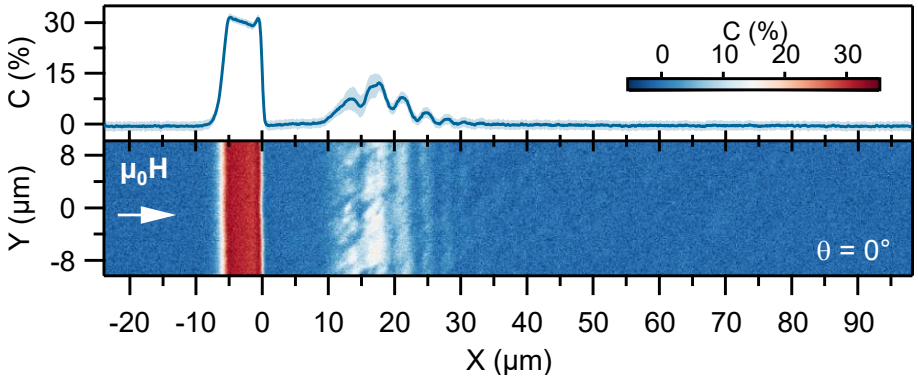


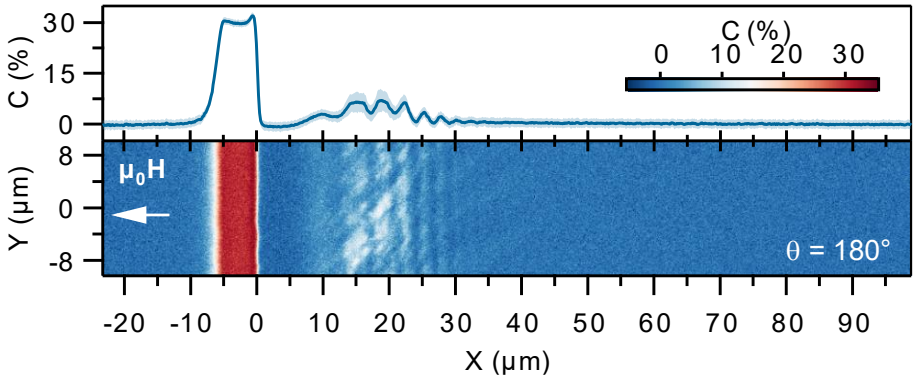
Field-control of spin waves



In-plane field dependence

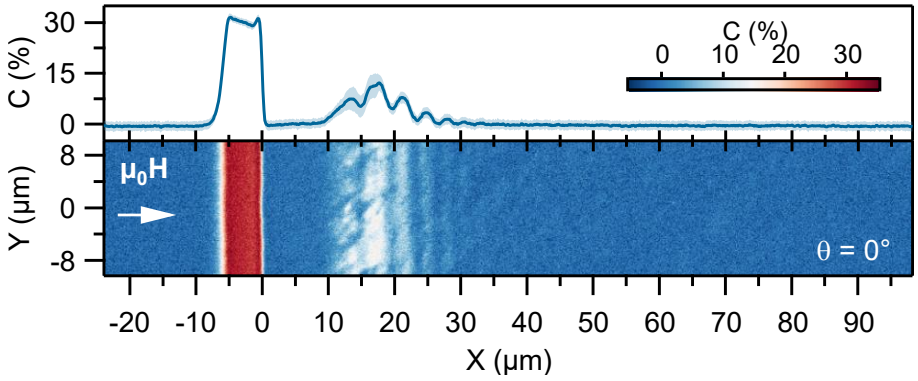
$\mu_0\vec{H} \parallel \vec{k}$

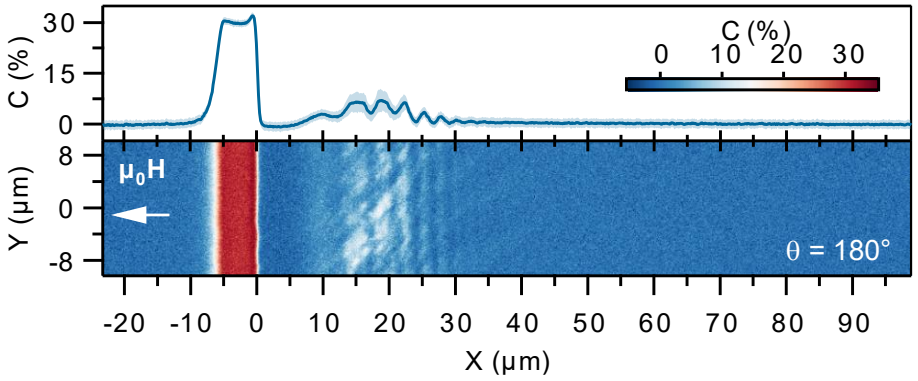




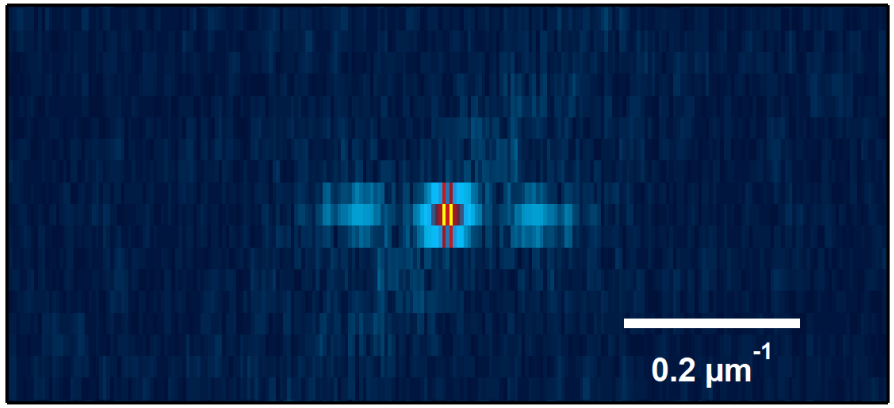
In-plane field dependence

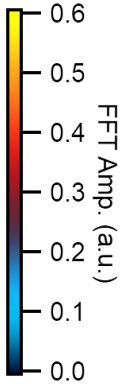
$\mu_0 \vec{H} \parallel \vec{k}$

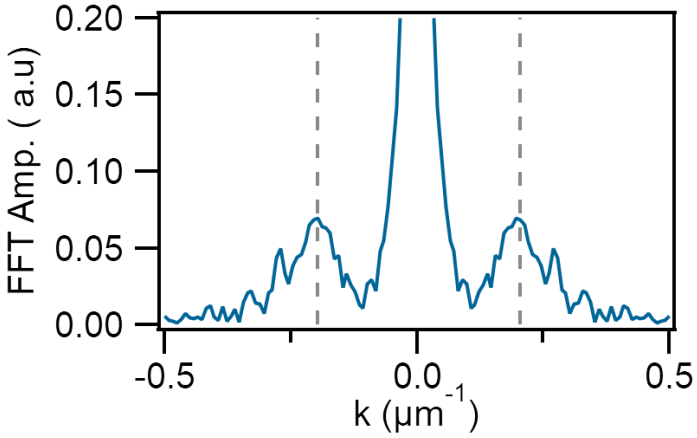




$\lambda \sim 3.4\ \mu m$

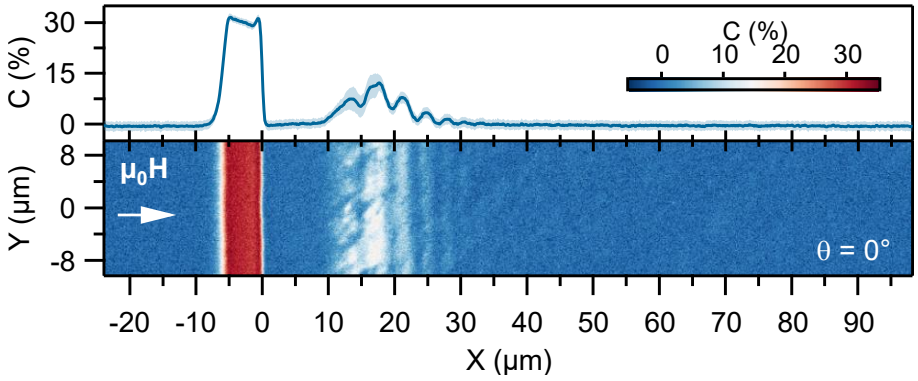


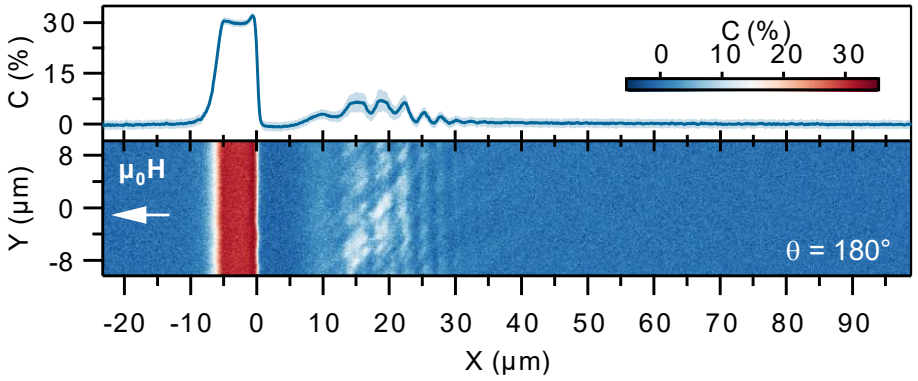




In-plane field dependence

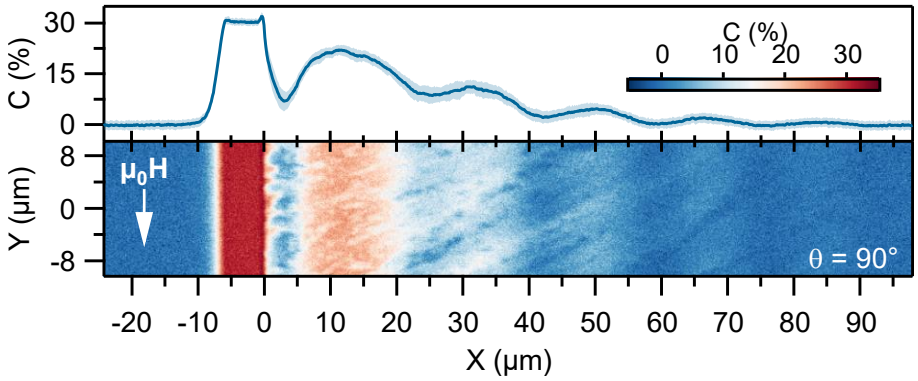
$\mu_0 \vec{H} \parallel \vec{k}$

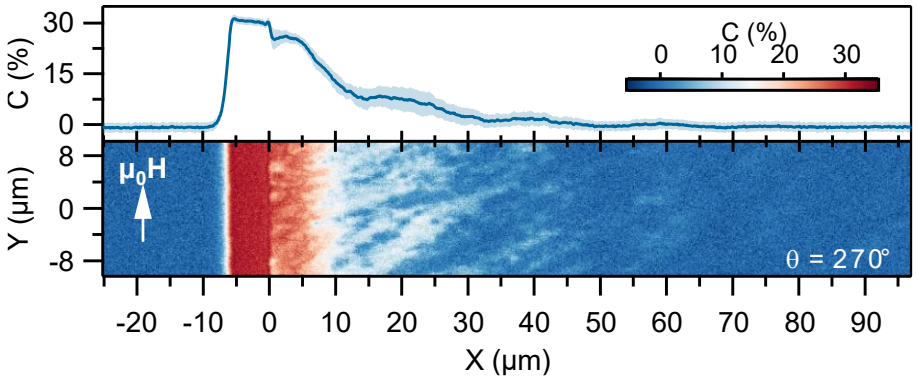




$\lambda \sim 3.4$ µm

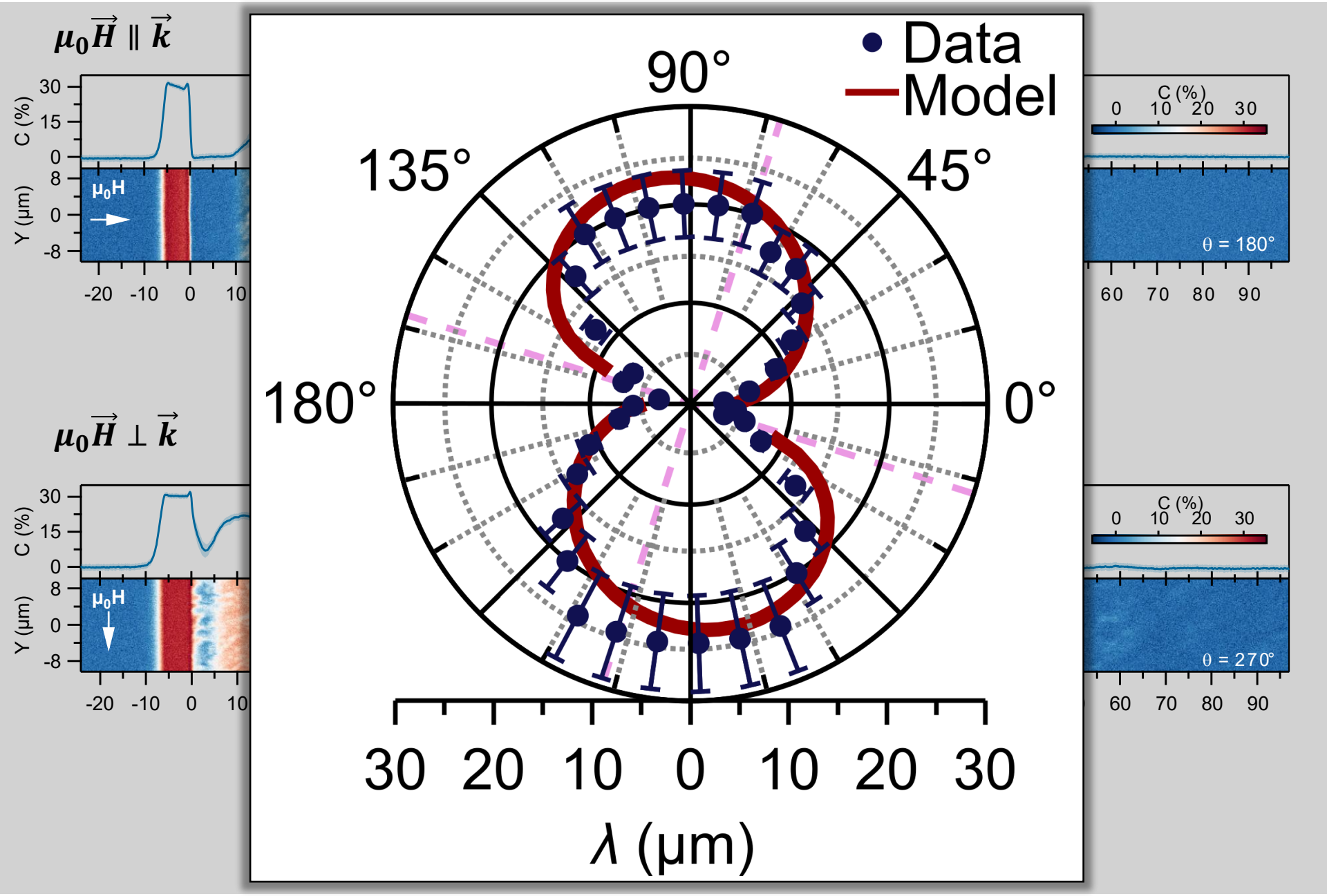
$\mu_0 \vec{H} \perp \vec{k}$





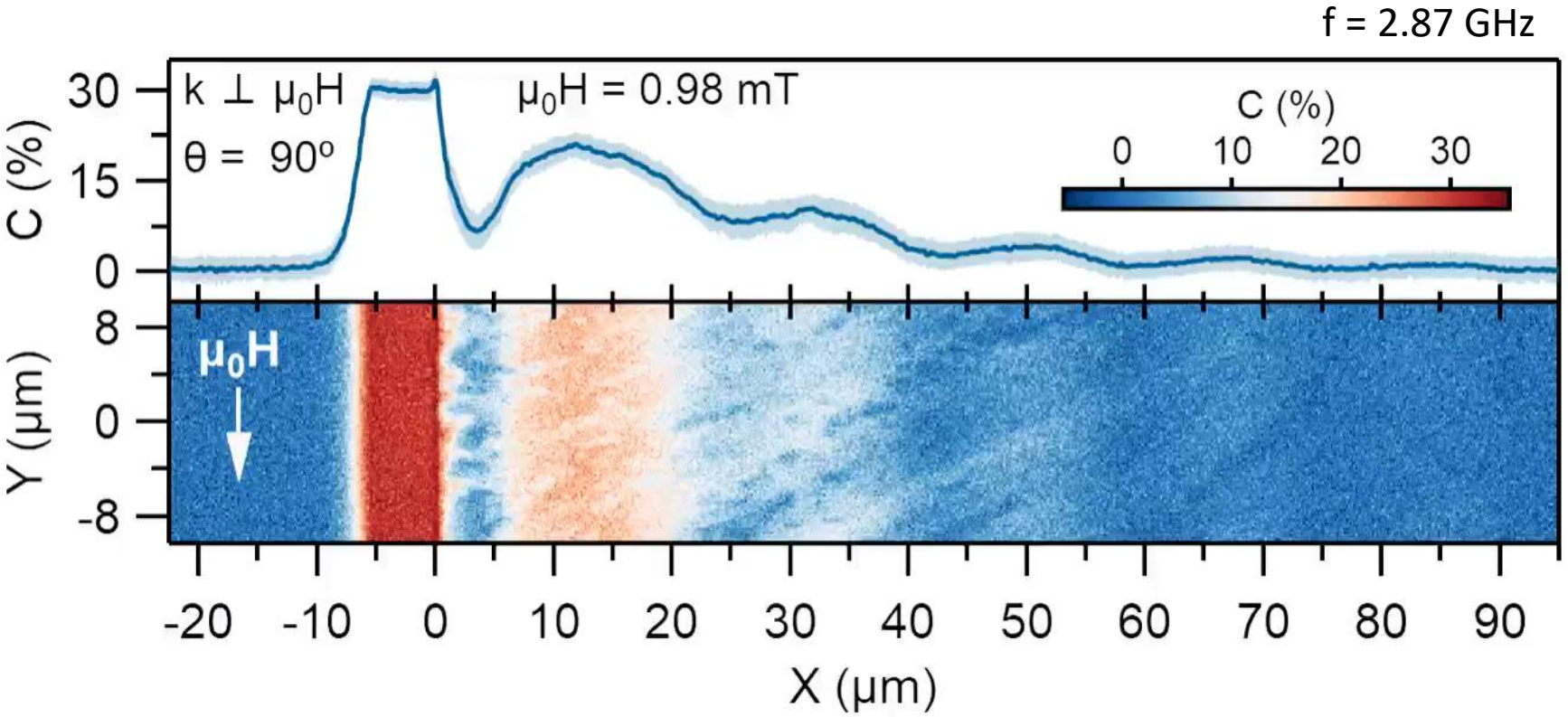
$\lambda \sim 20$ µm

In-plane field dependence



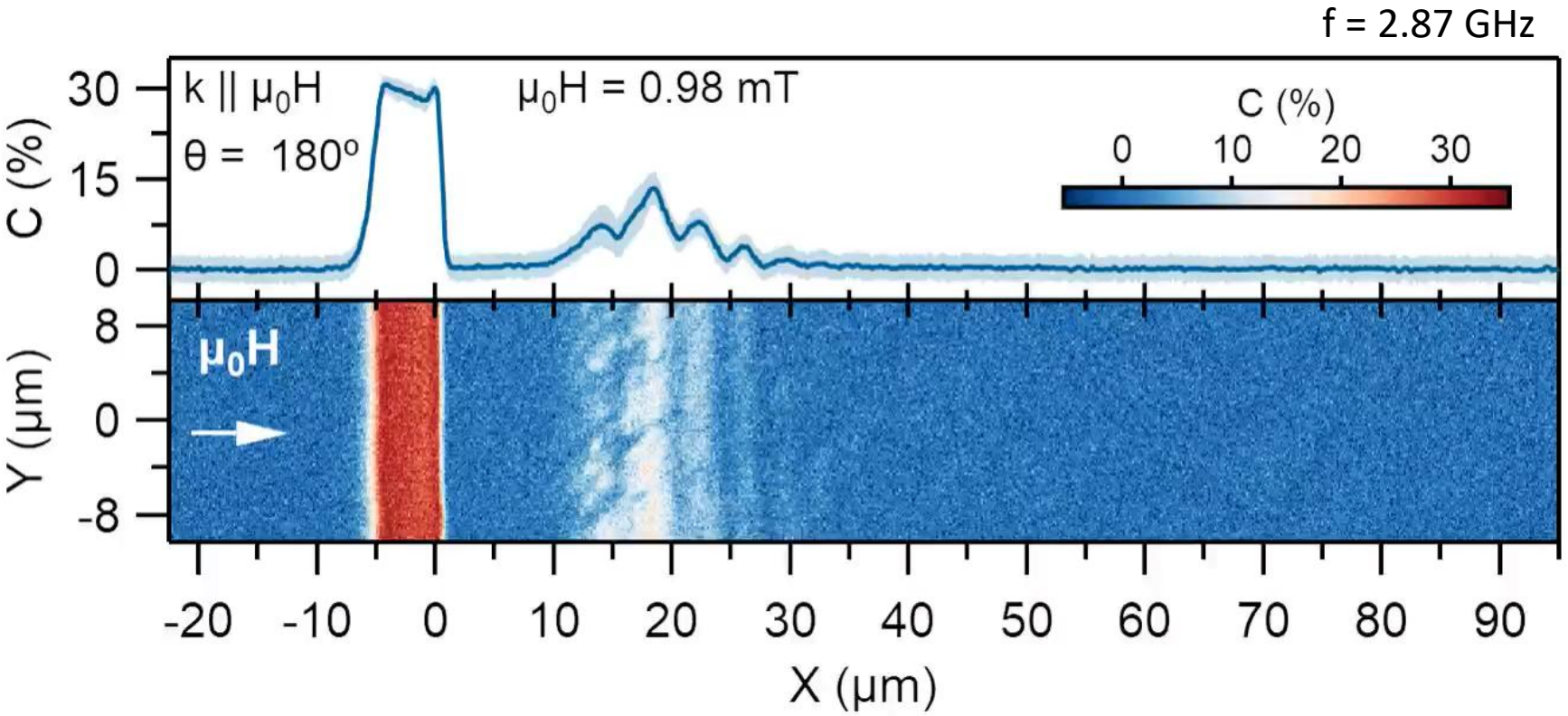
Field strength dependence

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

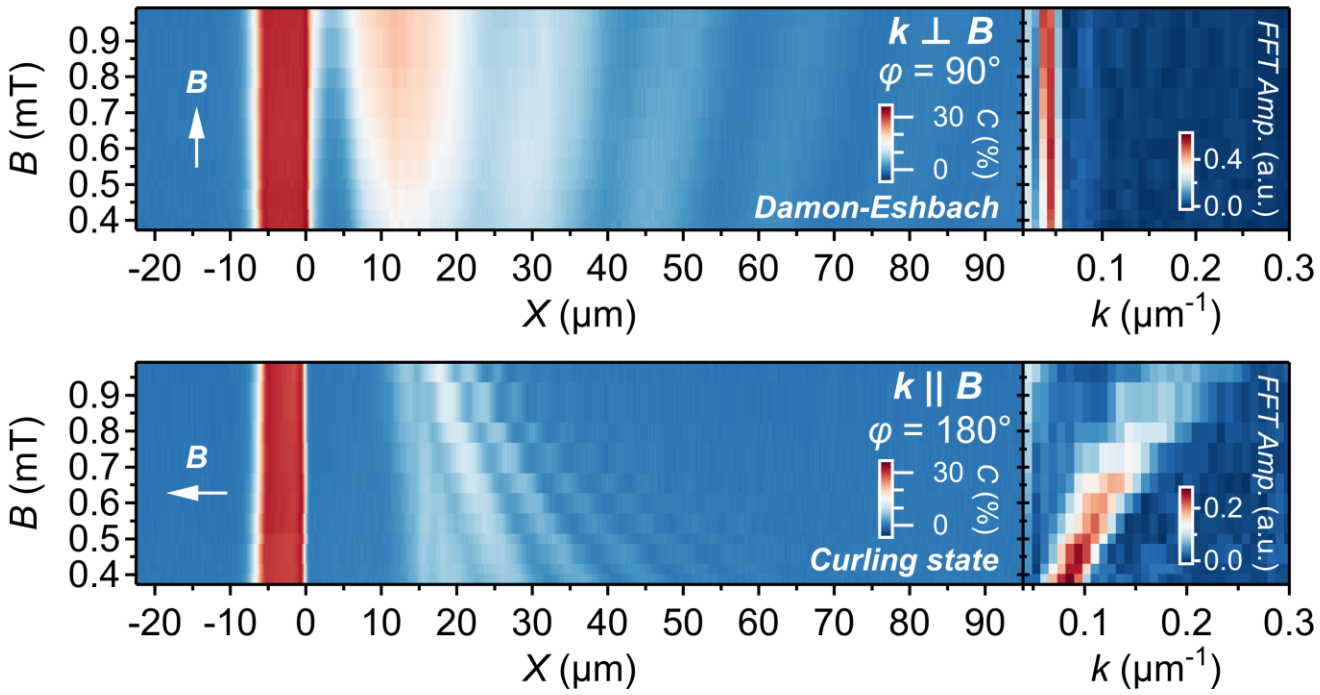


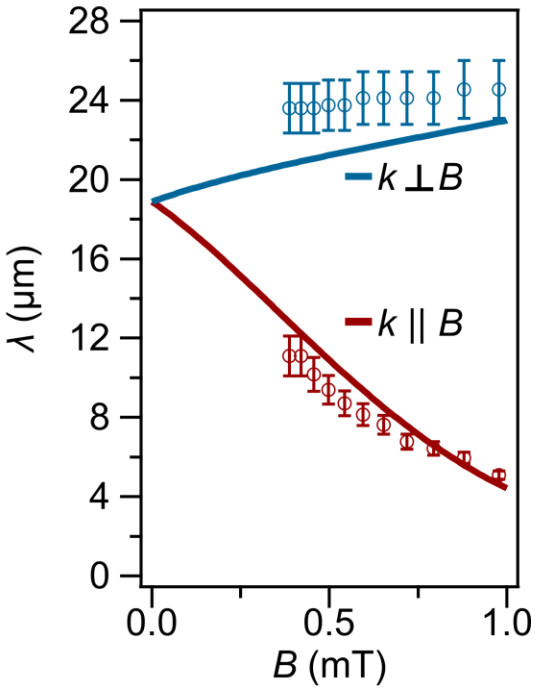
Field strength dependence

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

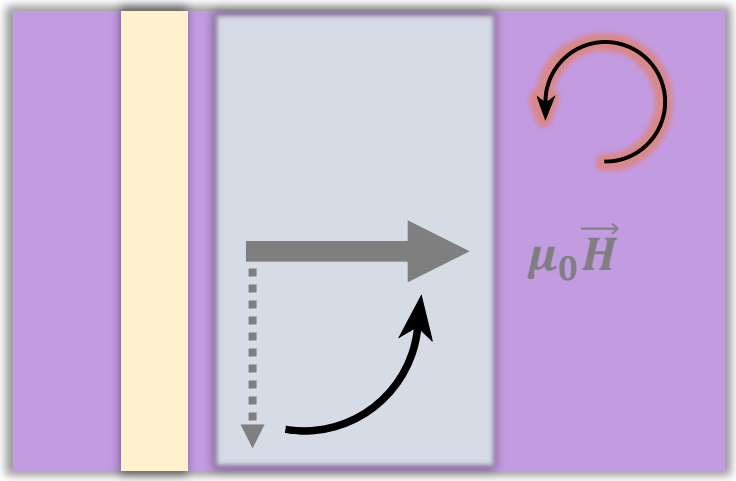


Field strength dependence

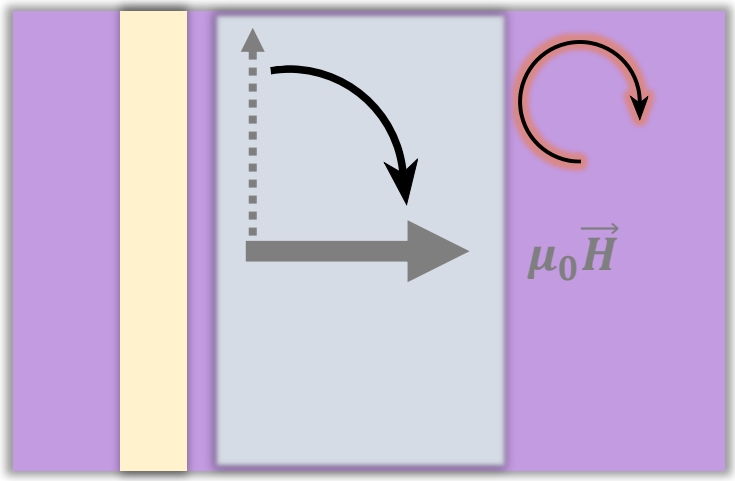




Bistability at the edge: field-control of spin textures

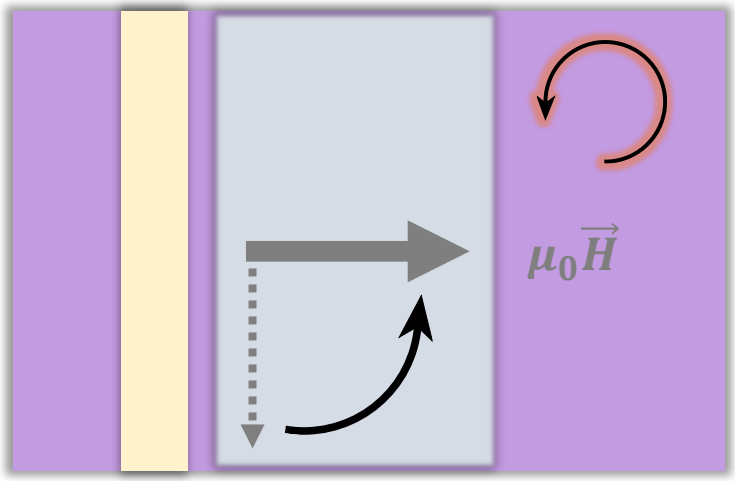


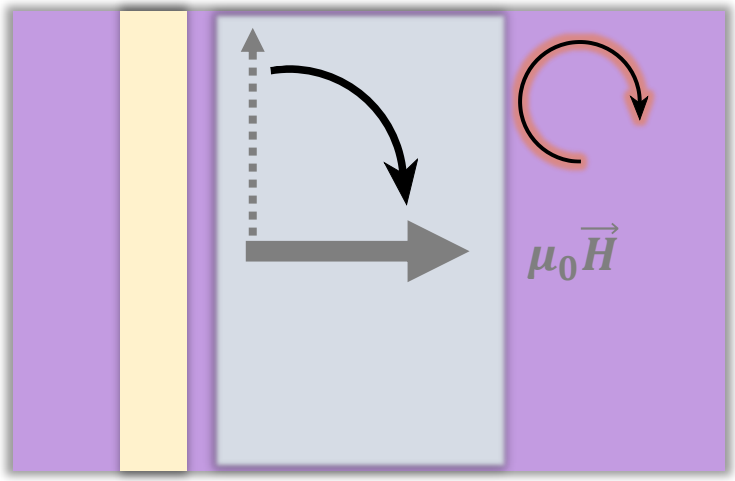
Si RF line Py

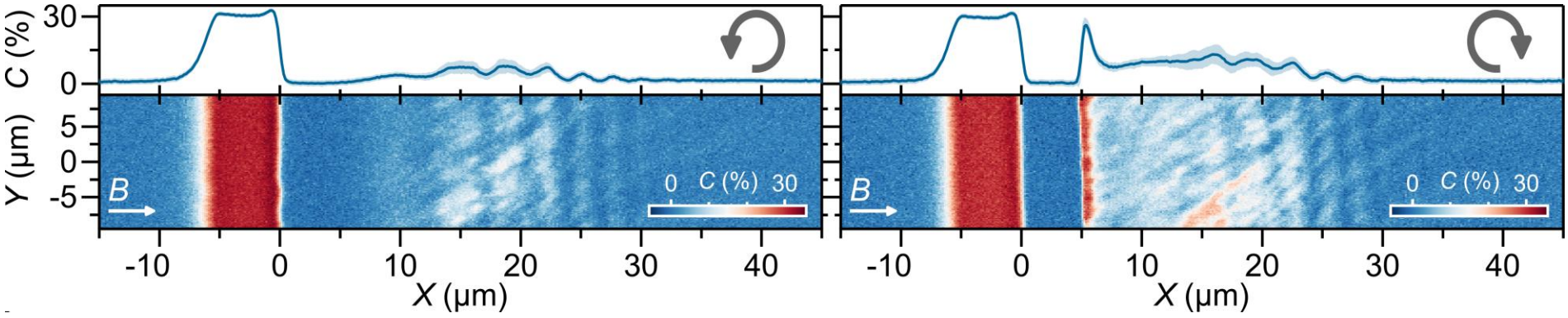


Si RF line Py

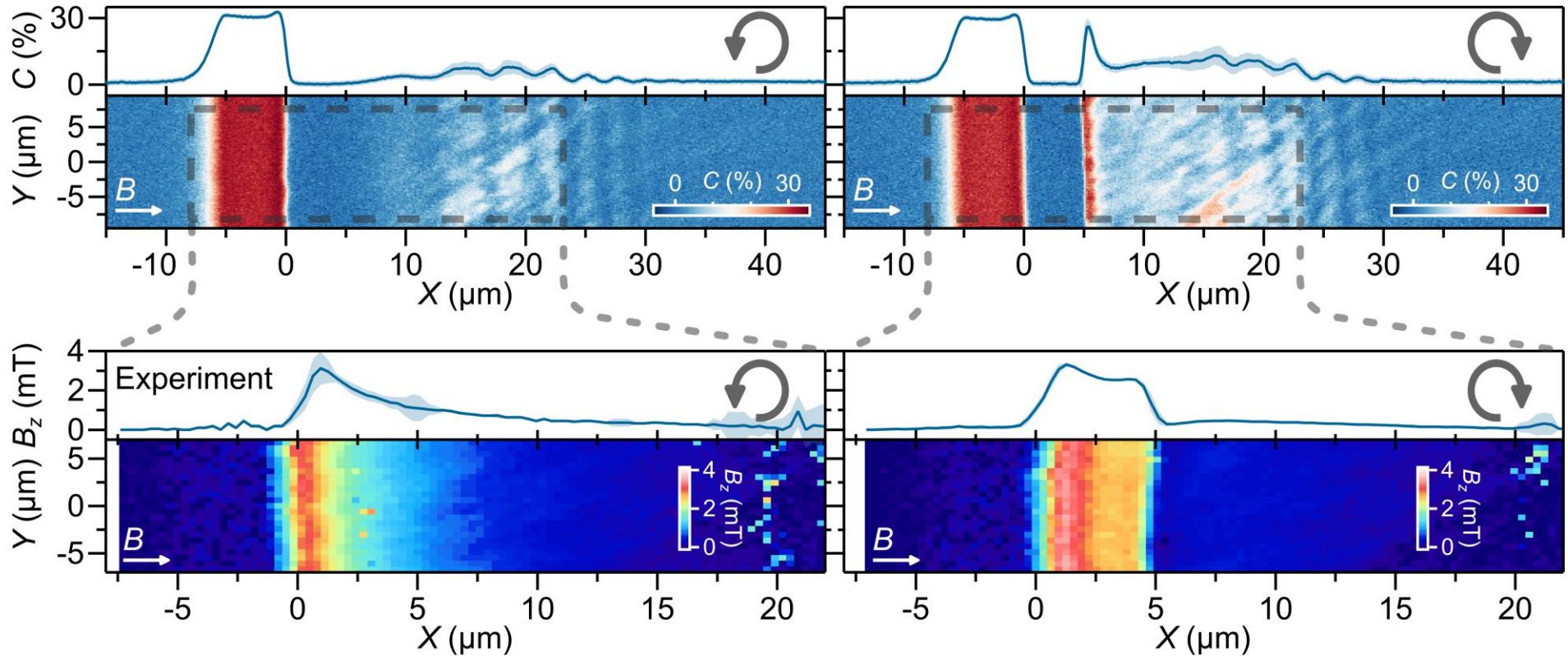
Bistability at the edge: field-control of spin textures



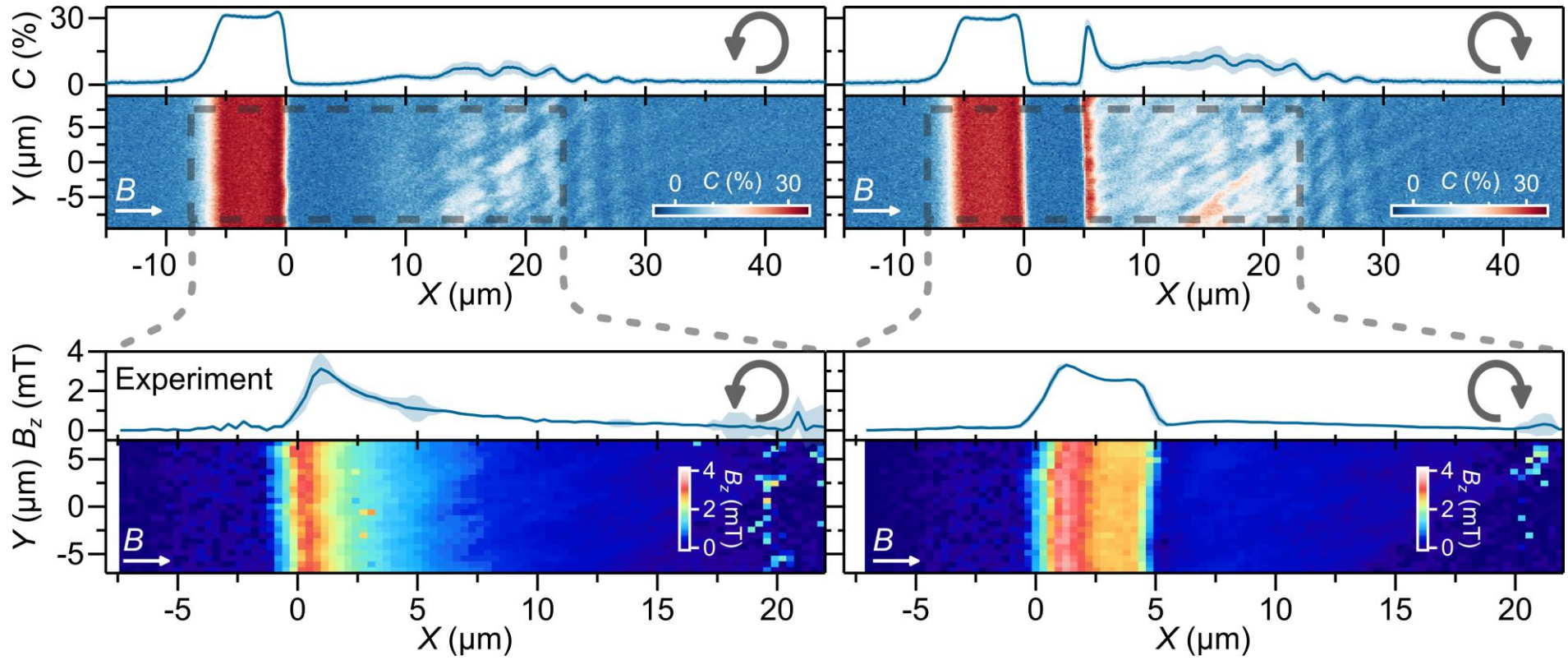




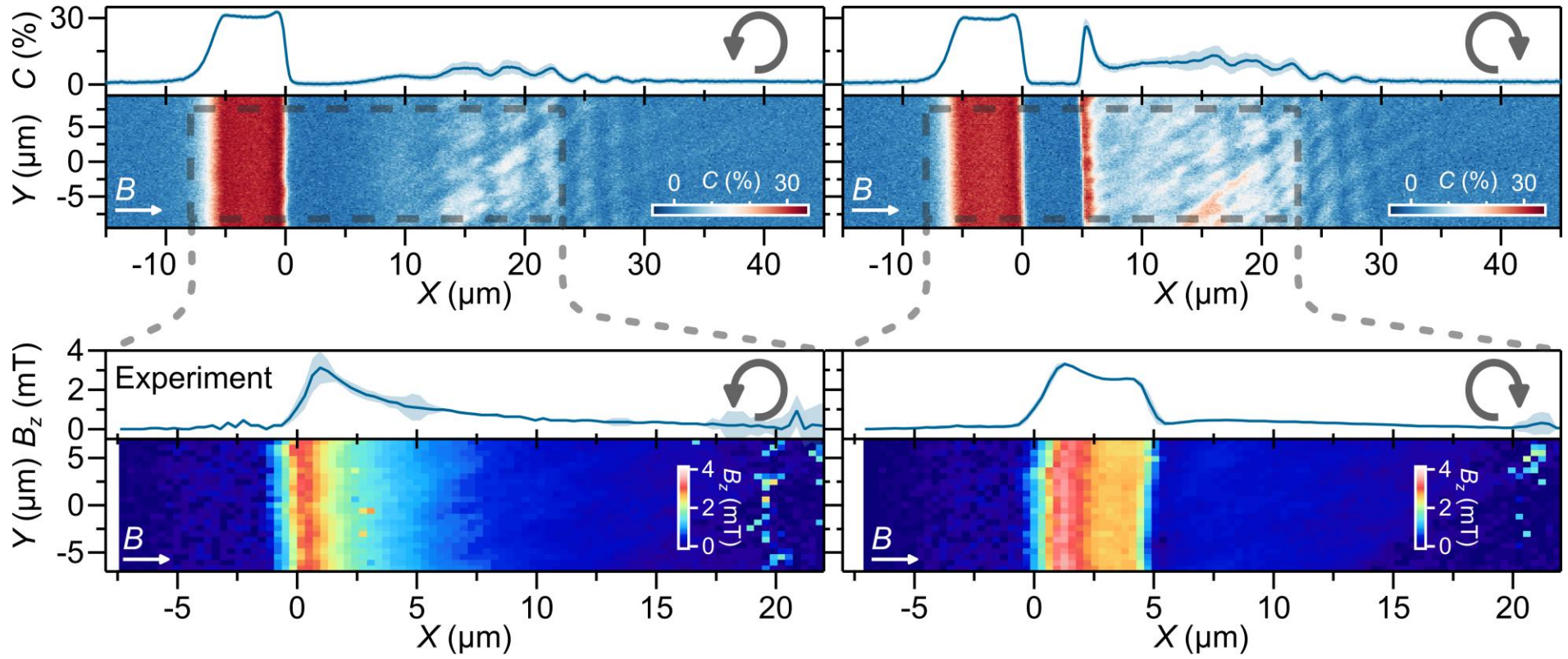
Bistability at the edge: field-control of spin textures

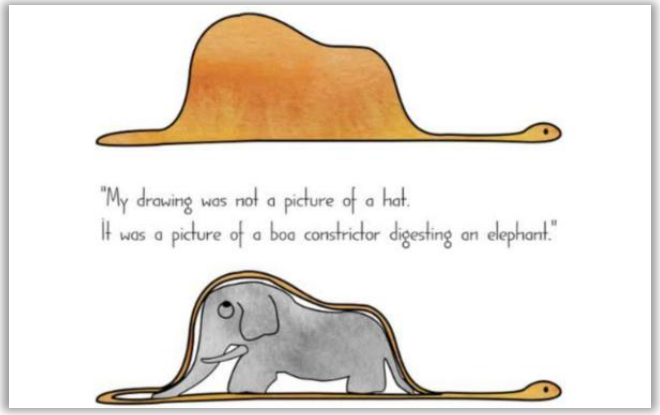


Bistability at the edge: field-control of spin textures



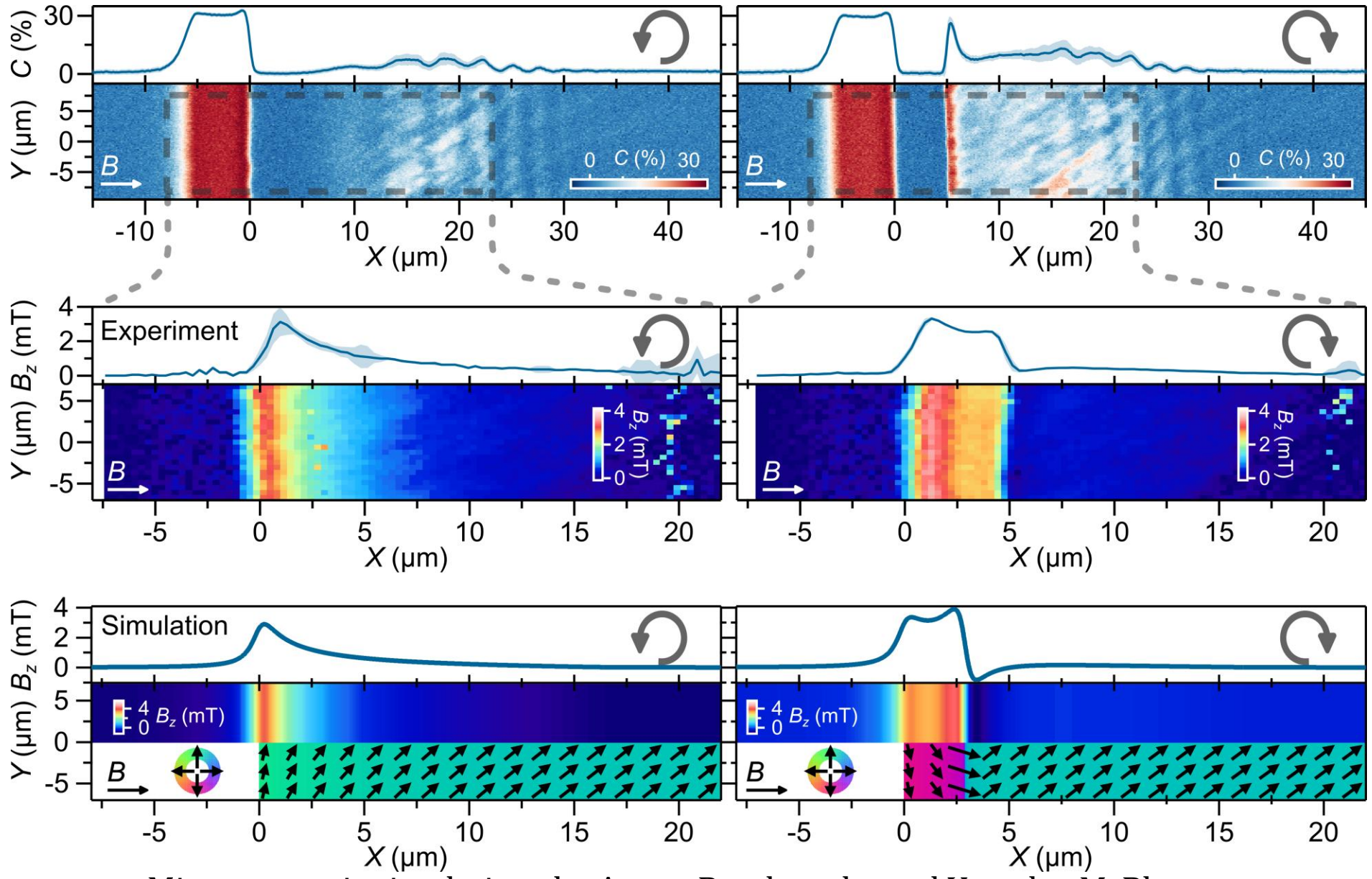
Bistability at the edge: field-control of spin textures





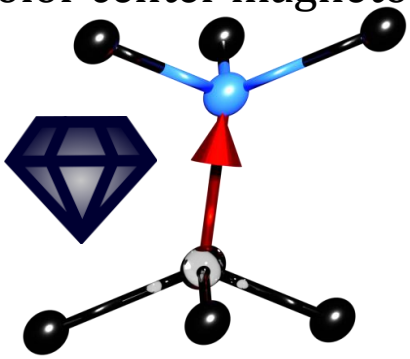
Antoine de Saint-Exupéry, The Little Prince

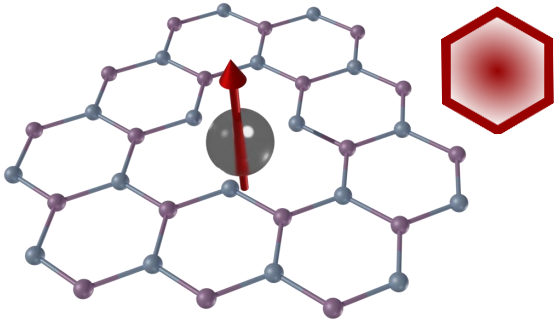
Bistability at the edge: field-control of spin textures

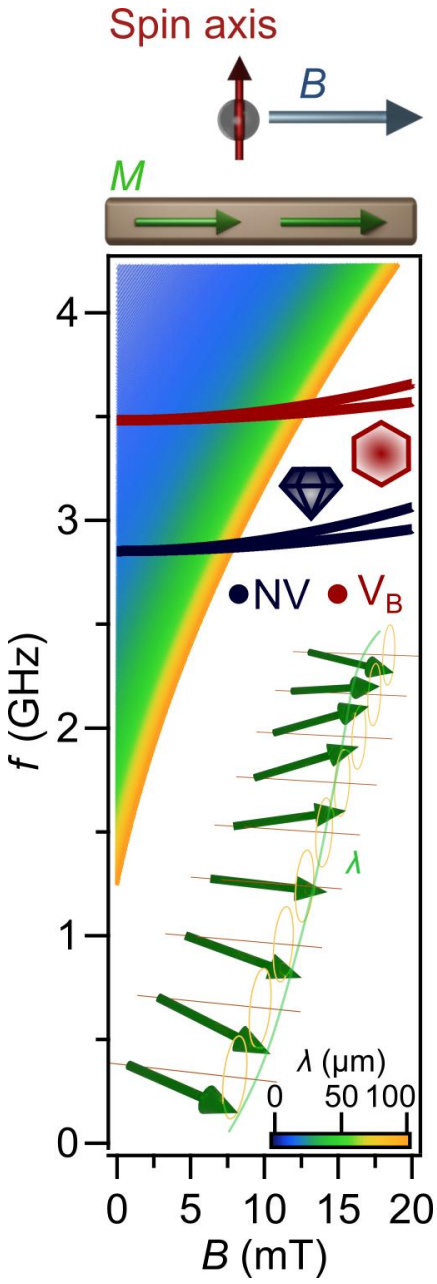


Micromagnetic simulations by Artem Bondarenko and Yaroslav M. Blanter

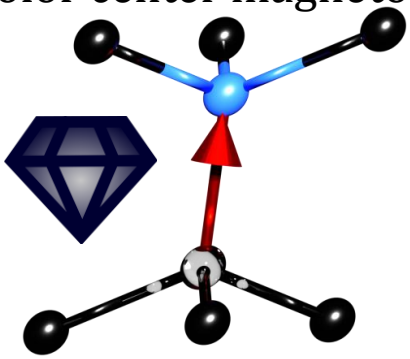
- Color center magnetometry for isofrequency spin-wave imaging.

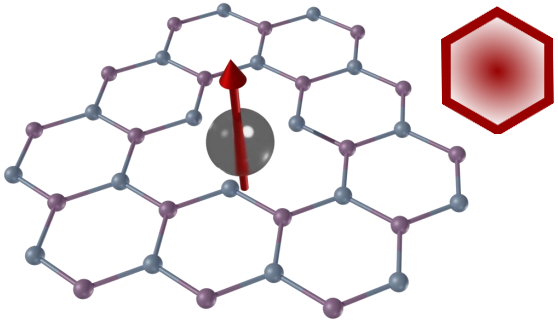




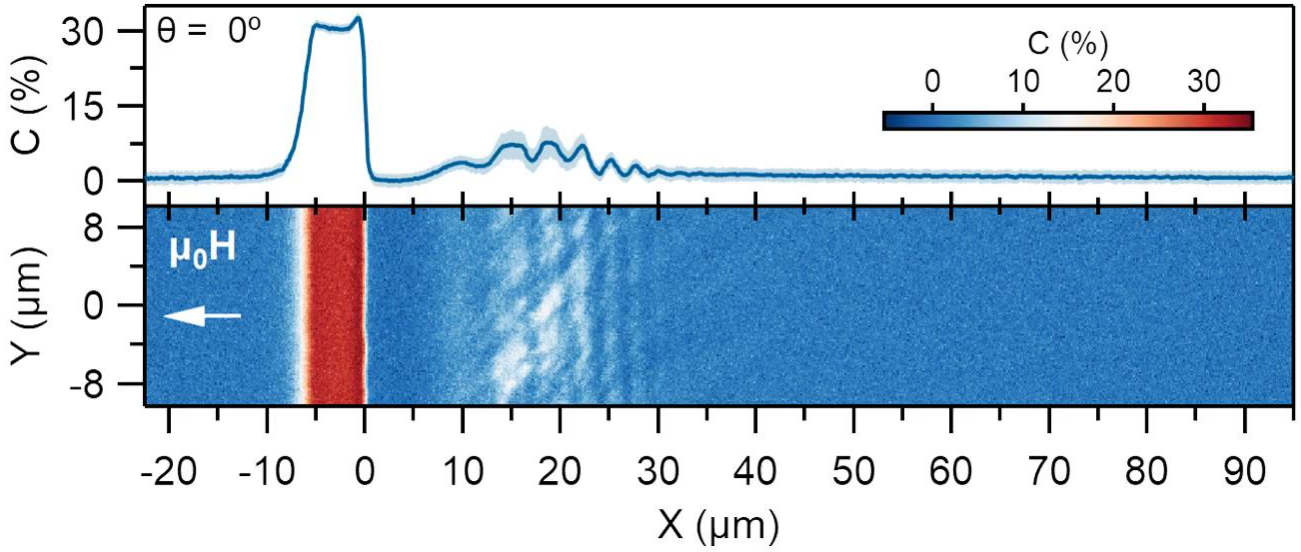


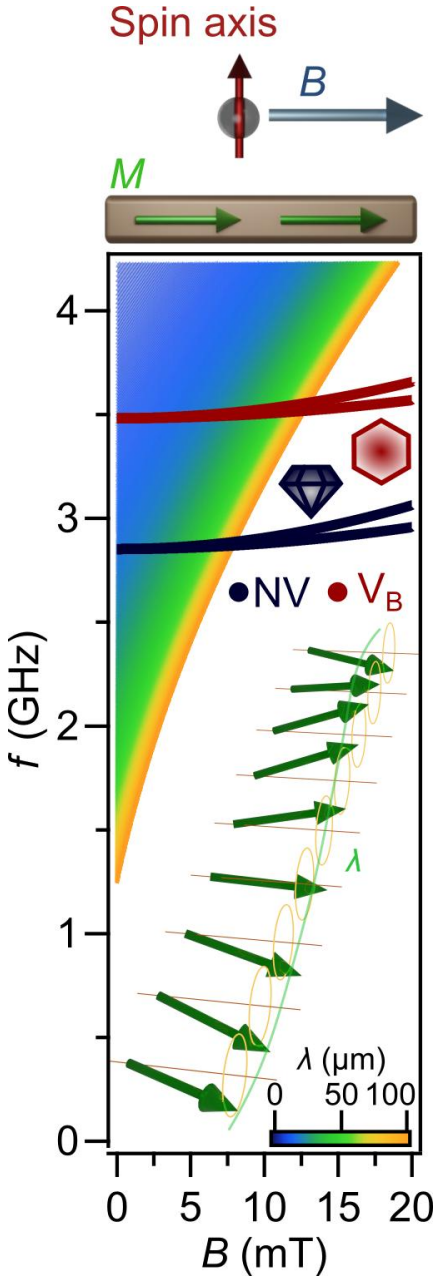
- Color center magnetometry for isofrequency spin-wave imaging.



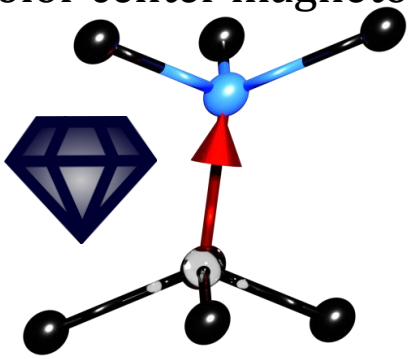


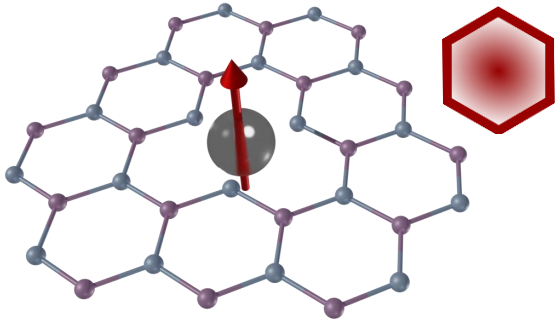
- Color center magnetometry as an ideal tool for detecting both spin-waves and local static fields, revealing the role of inhomogeneous magnetization.



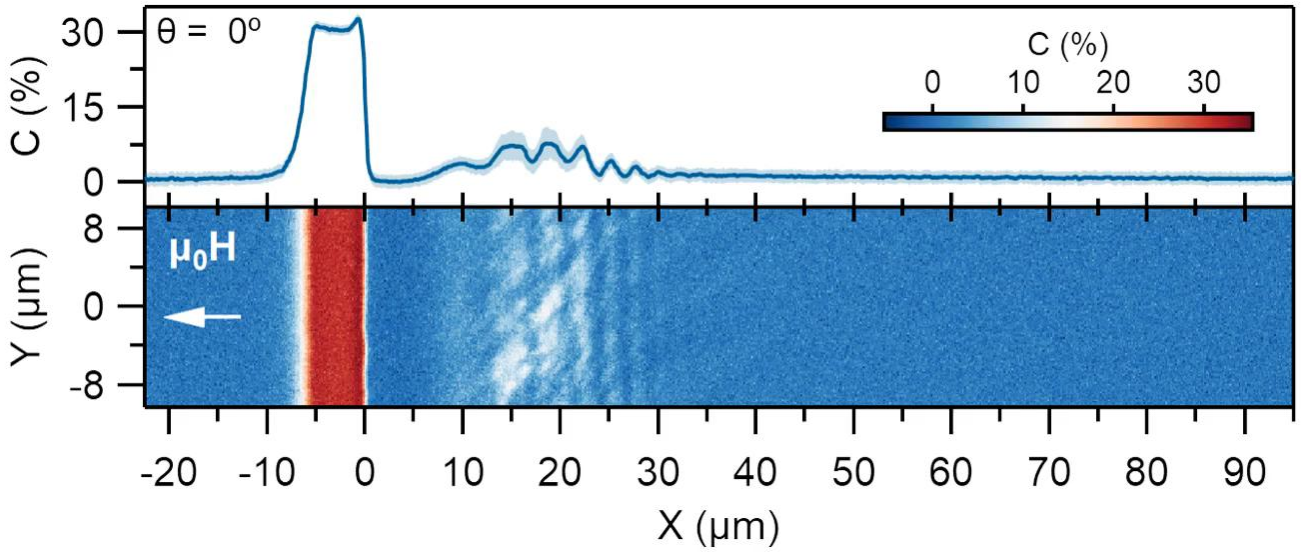


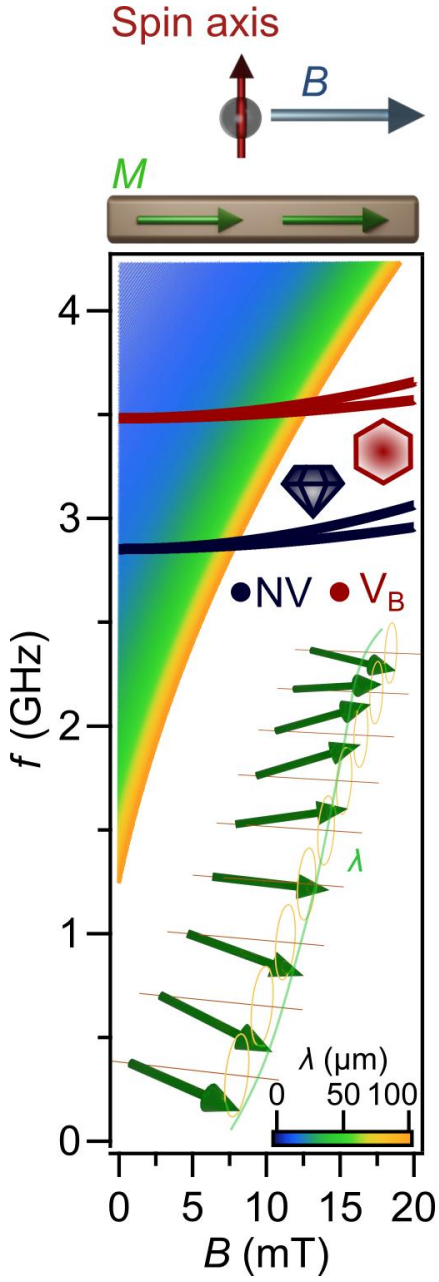
- Color center magnetometry for isofrequency spin-wave imaging.





- 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!