Ferromagnetic resonance studies of ferromagnets and superconductors

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H. Kurebayashi

L.F. Cohen

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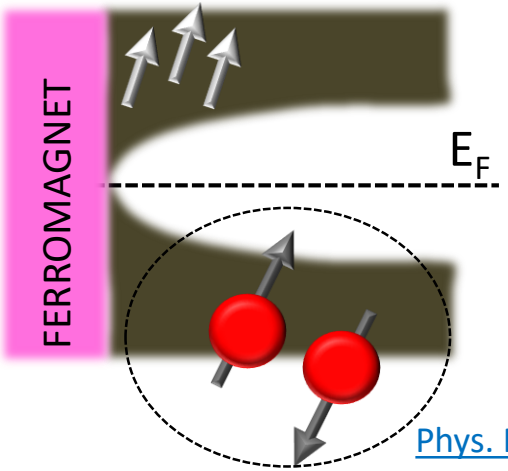
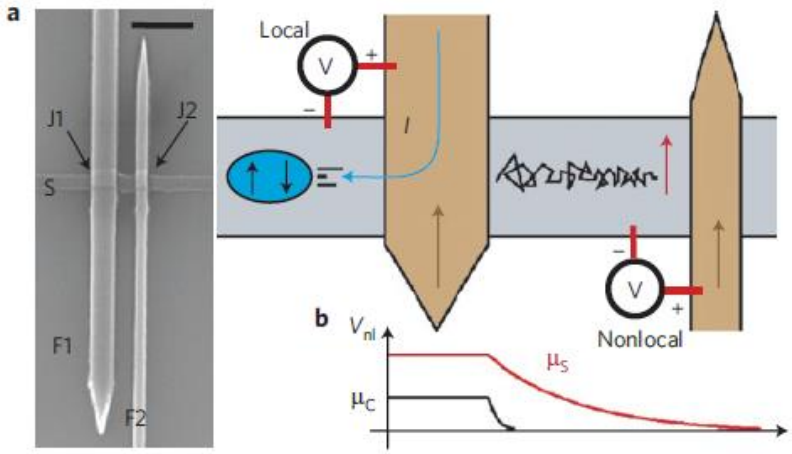
M. Eschrig

Spin transport within a superconductor



Phys. Rev. Lett. 74, 314317
Phys. Rev. Lett. 96, 037004 (2006)
Phys. Rev. Lett. 89, 267001 (2002).



Nature Physics 9, 84 (2013)

ARTICLES
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nature materials

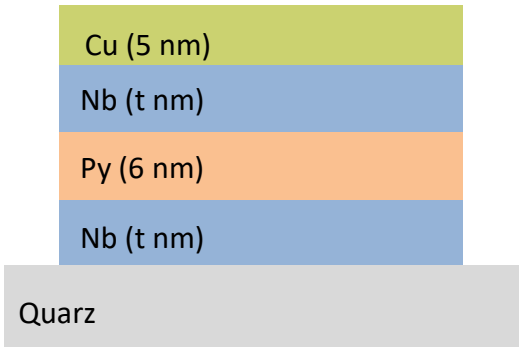
Extremely long quasiparticle spin lifetimes in superconducting aluminium using MgO tunnel spin injectors

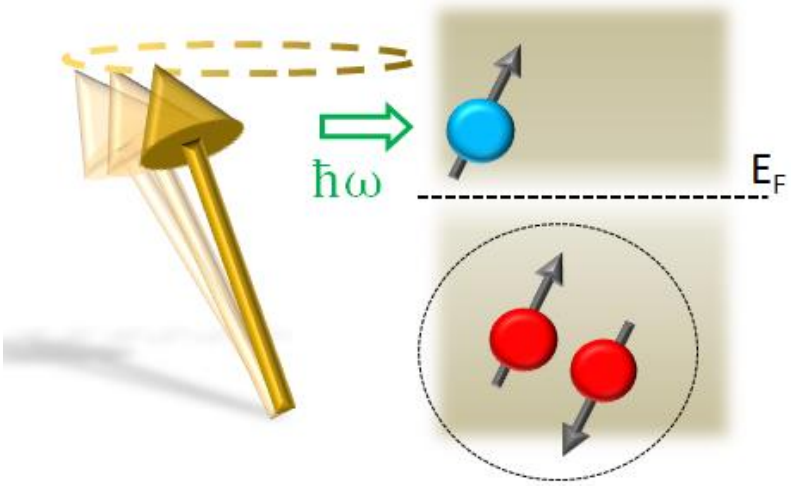
Hyunsoo Yang[1†‡], See-Hun Yang[1†], Saburo Takahashi[2,3], Sadamichi Maekawa[3,4] and Stuart S. P. Parkin[1*]

Nature Mater. 9, 586 (2010)

We measure spin-pumping in a superconductor

Layout 1





Nature Materials 17, 499 (2018)

We measure spin-pumping in a superconductor

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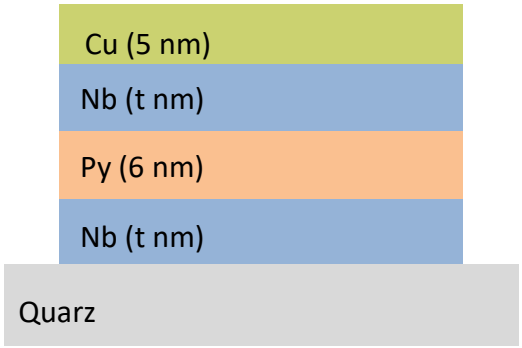
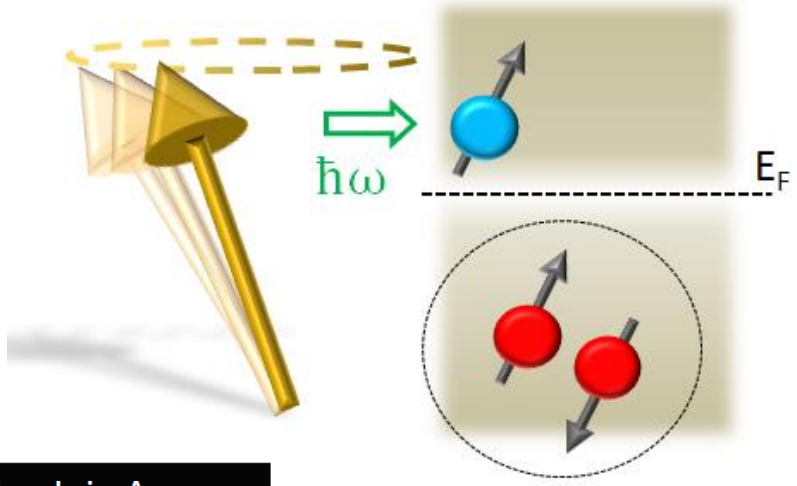
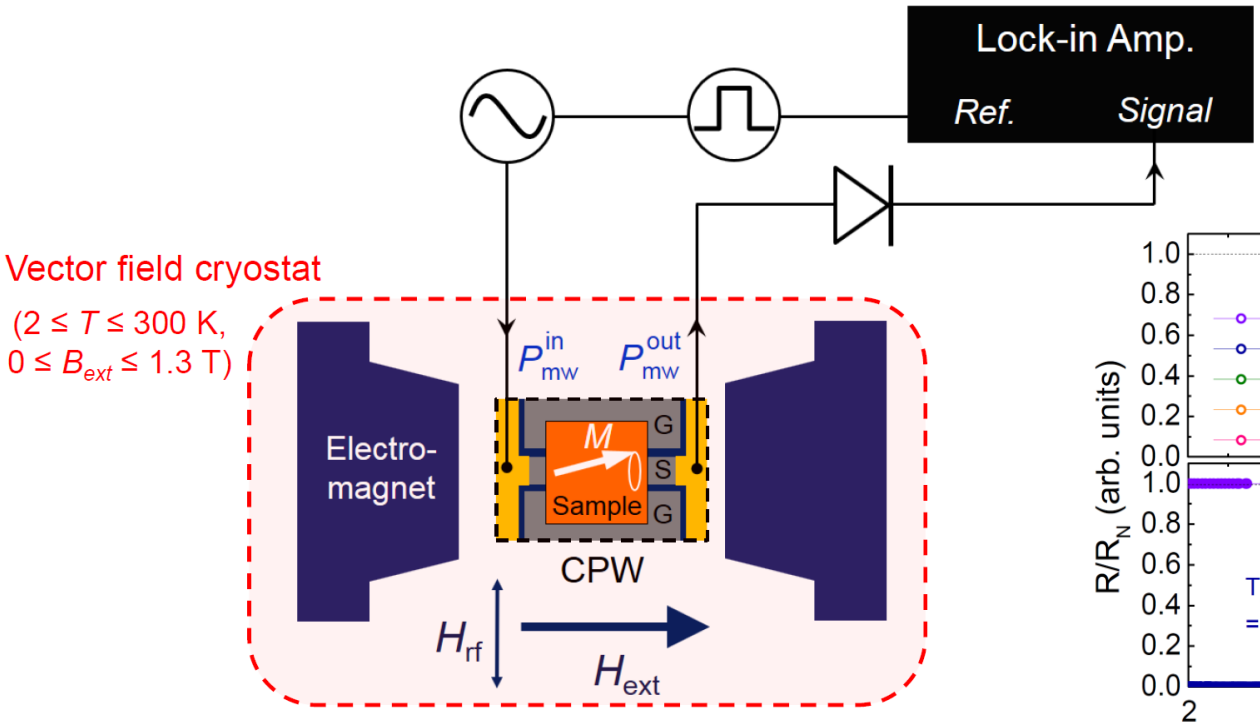
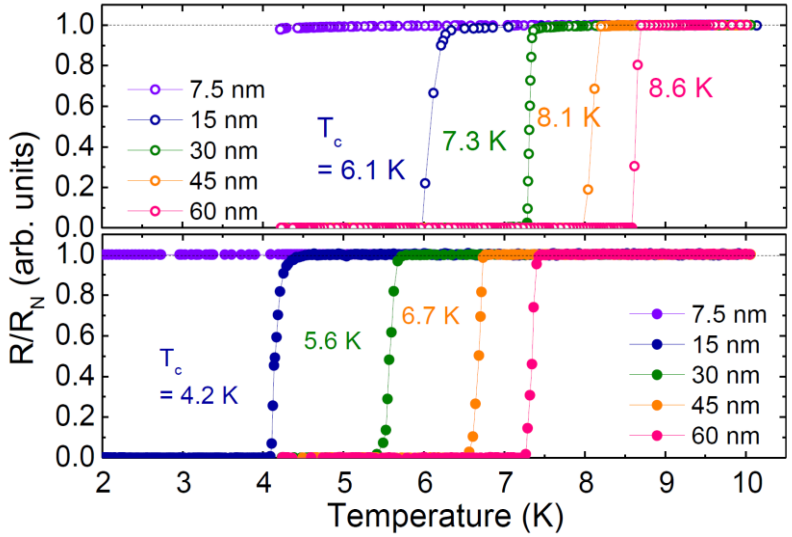
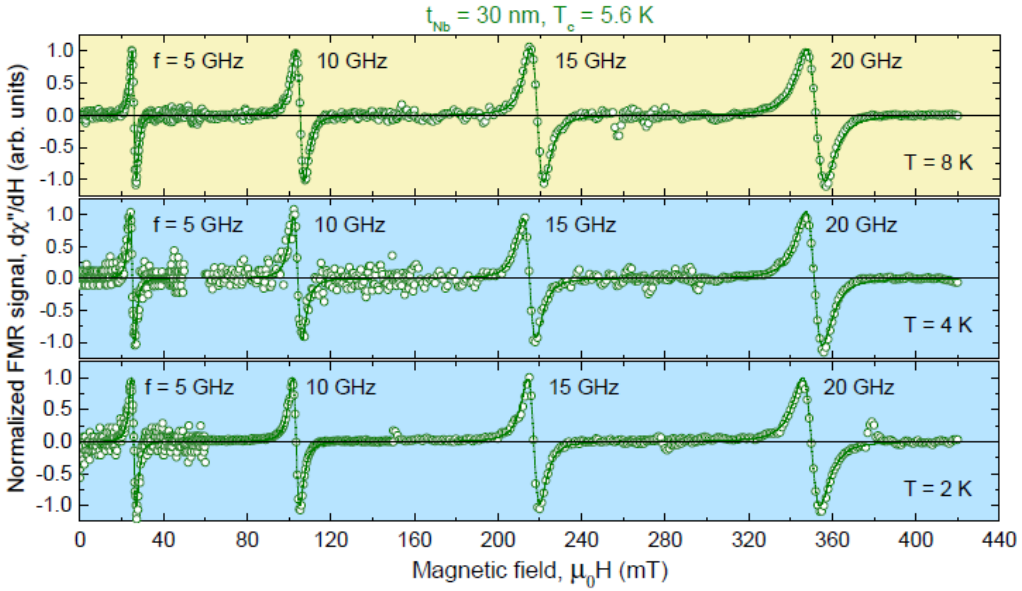








We estimate the spin through Nb from the FMR linewidth



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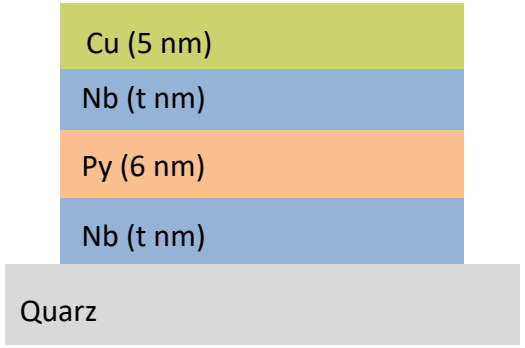

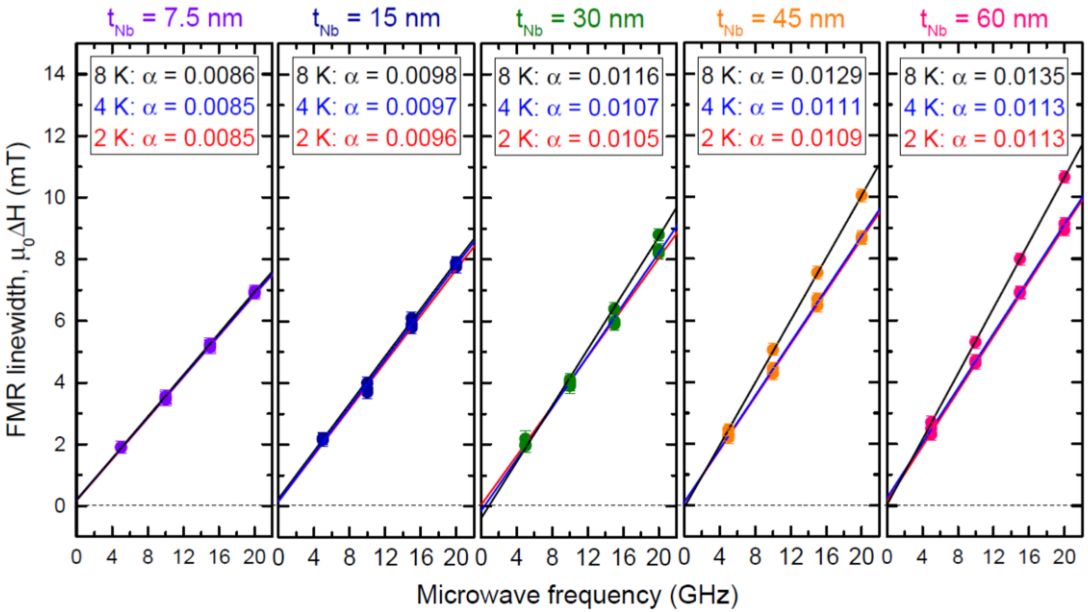

$$\mu_0\Delta H(f) = \mu_0\Delta H_0 + \frac{4\pi\alpha f}{\sqrt{3}\gamma}$$

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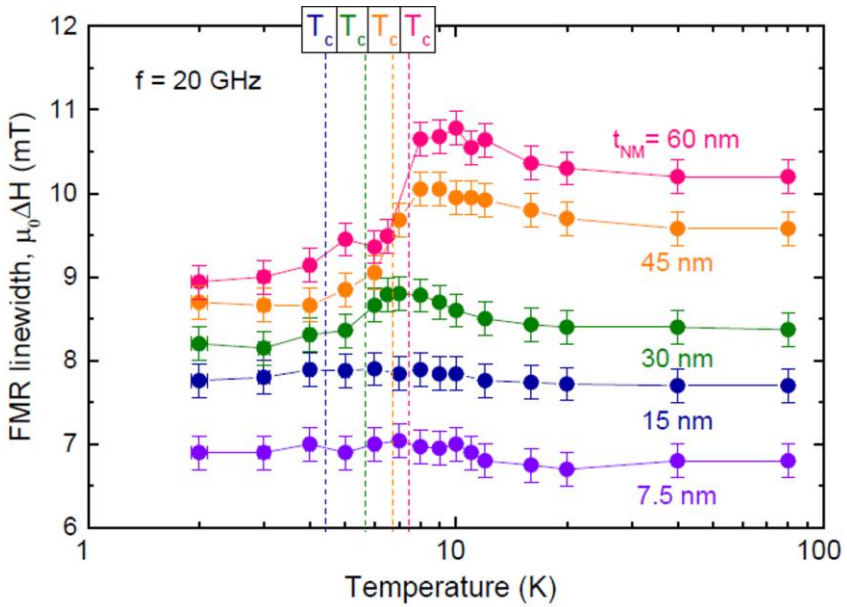
Damping has a sharp decrease below Tc



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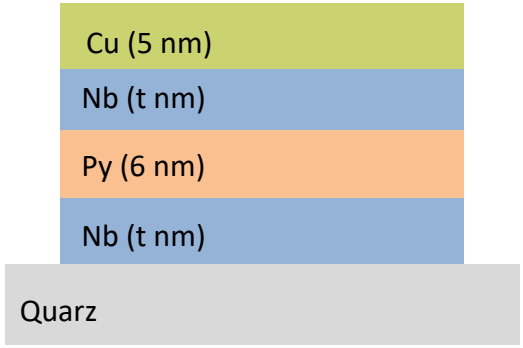

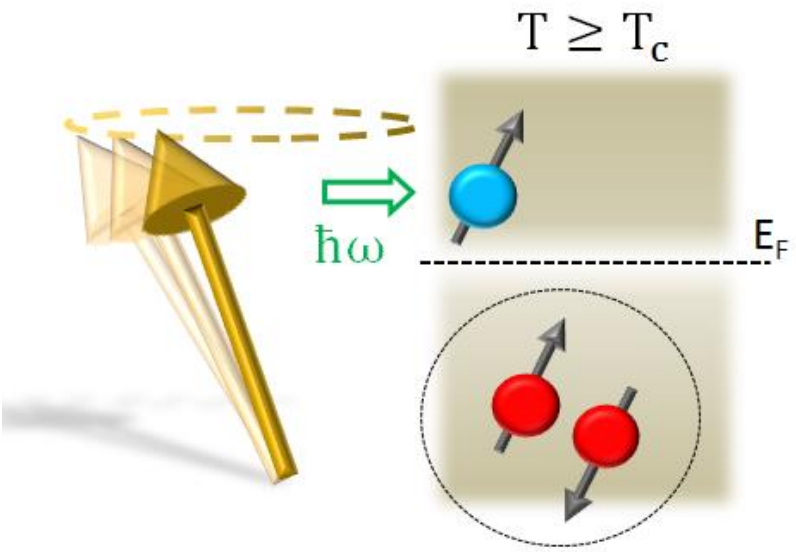

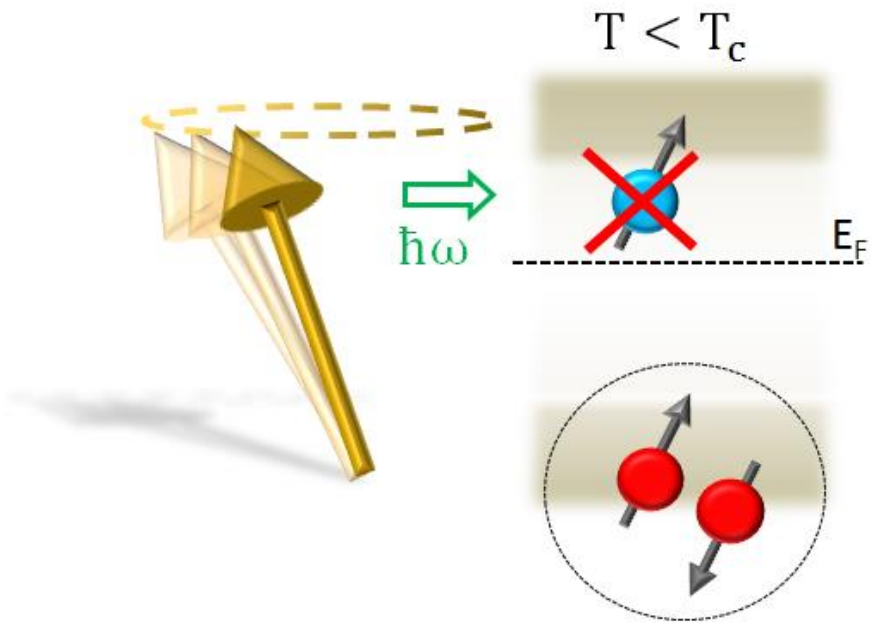

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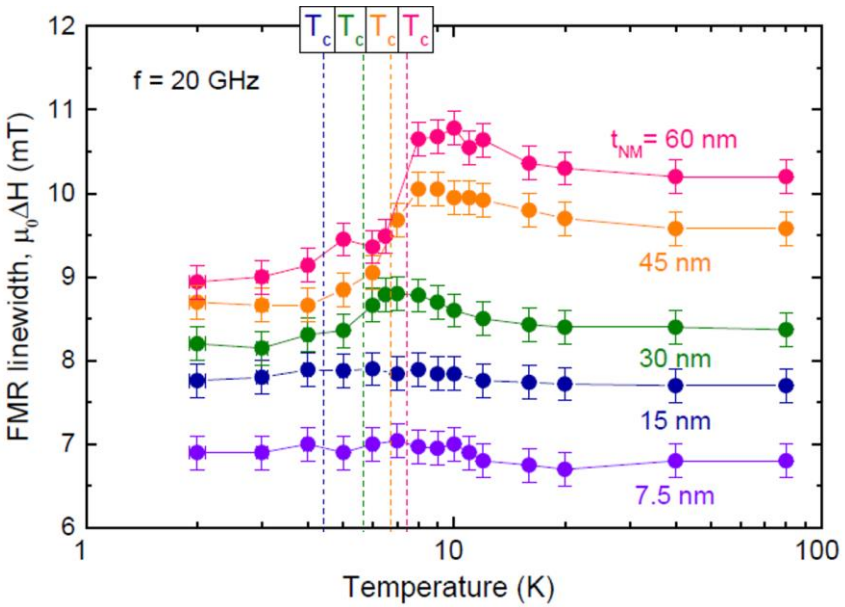

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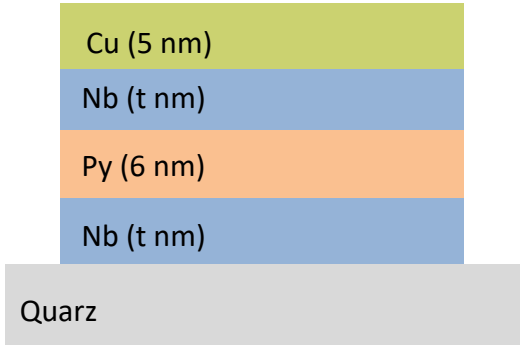
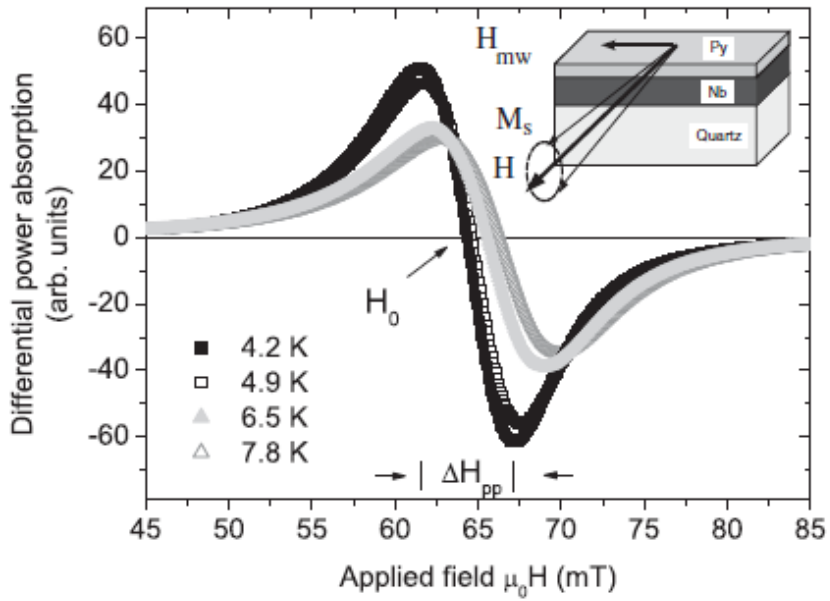
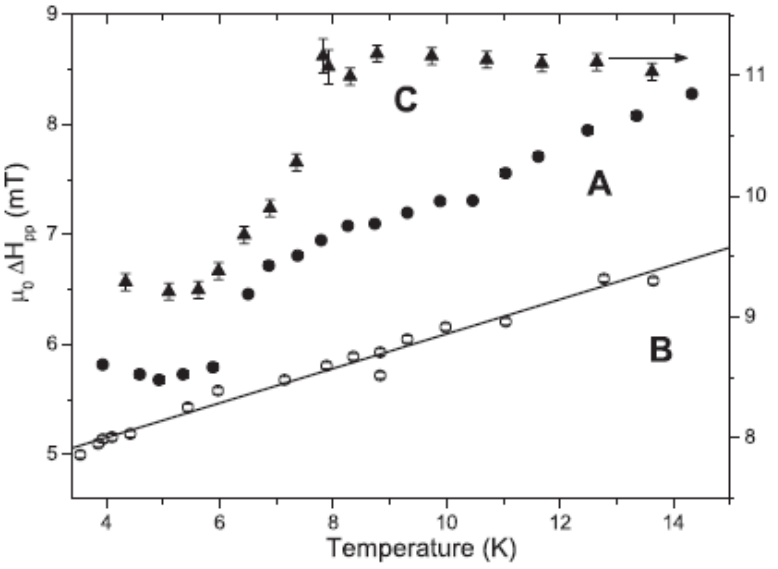
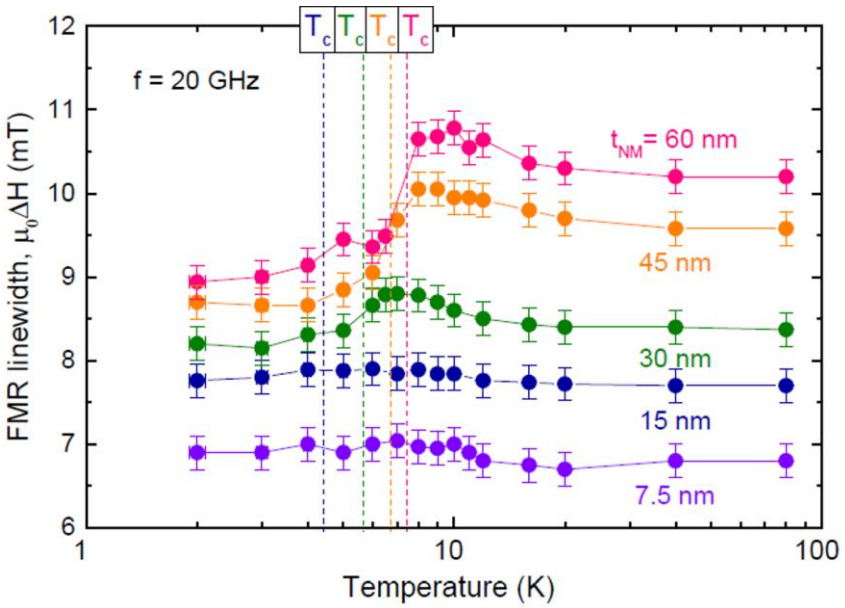






Phys. Rev. Lett. **100**, 047002 (2008)

Damping has a sharp decrease below Tc



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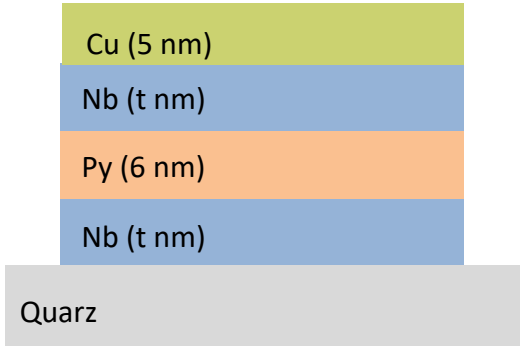
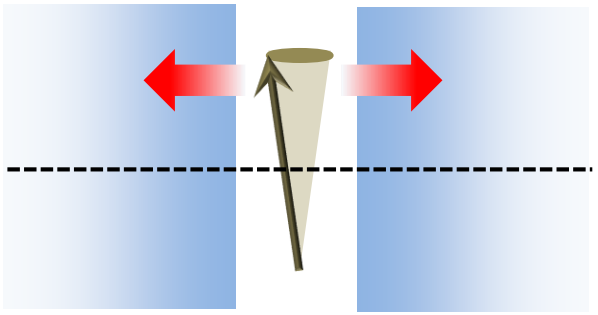
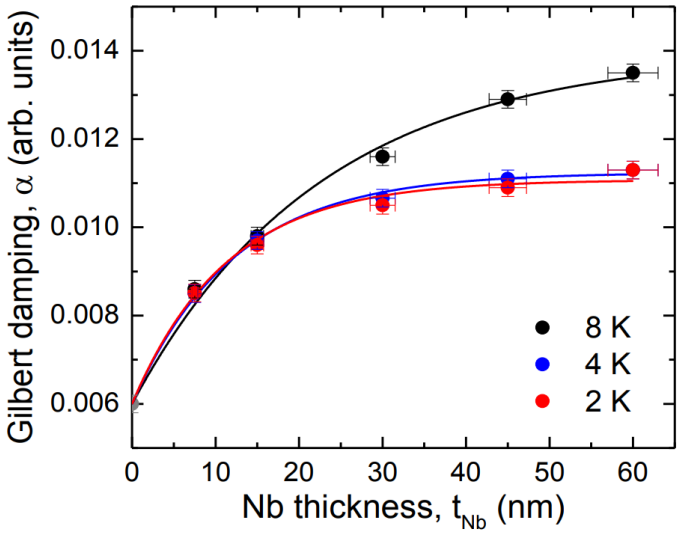
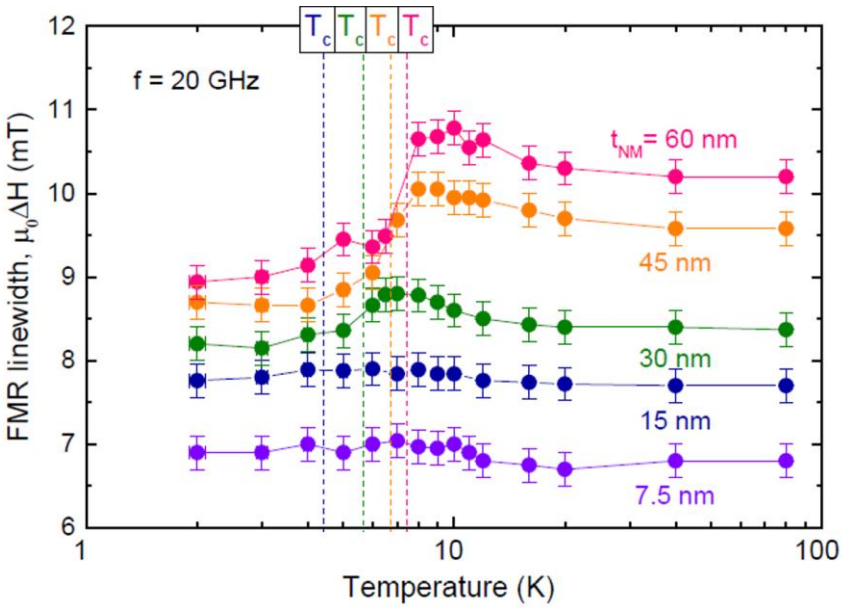






Damping has a sharp decrease below Tc



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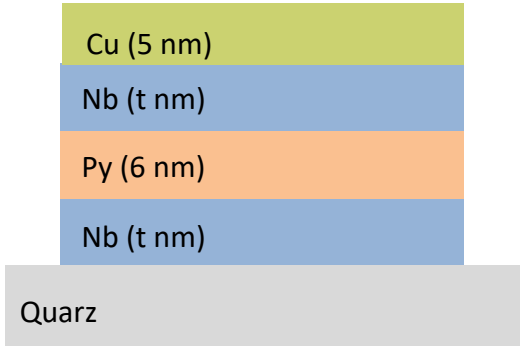

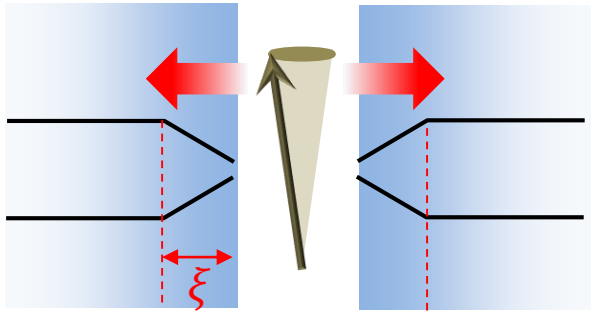

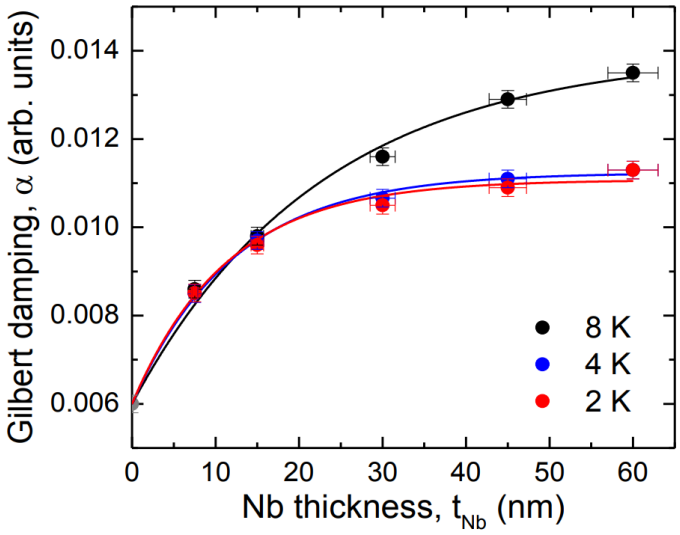

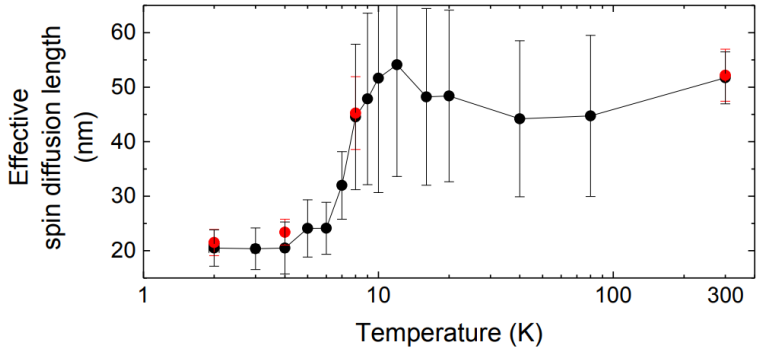

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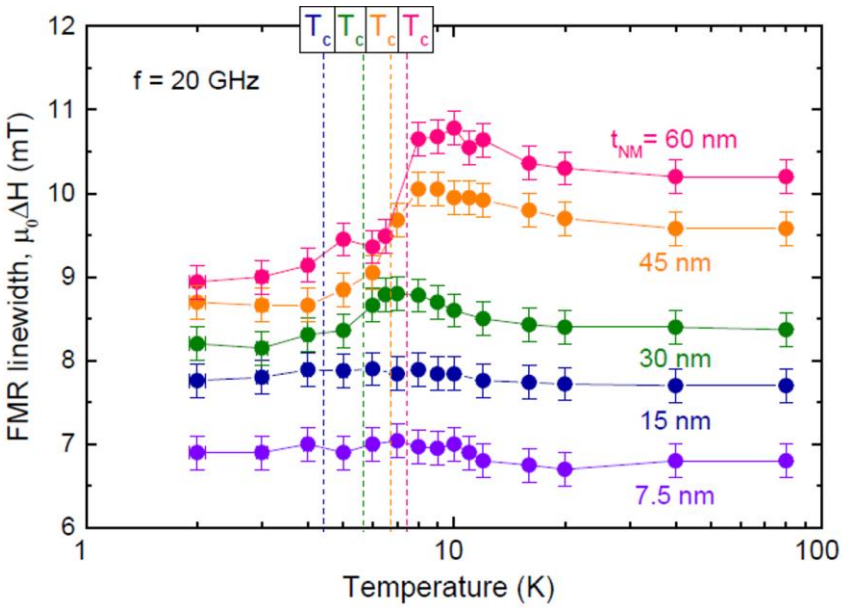

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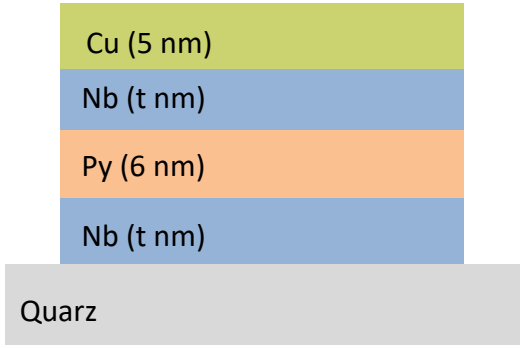
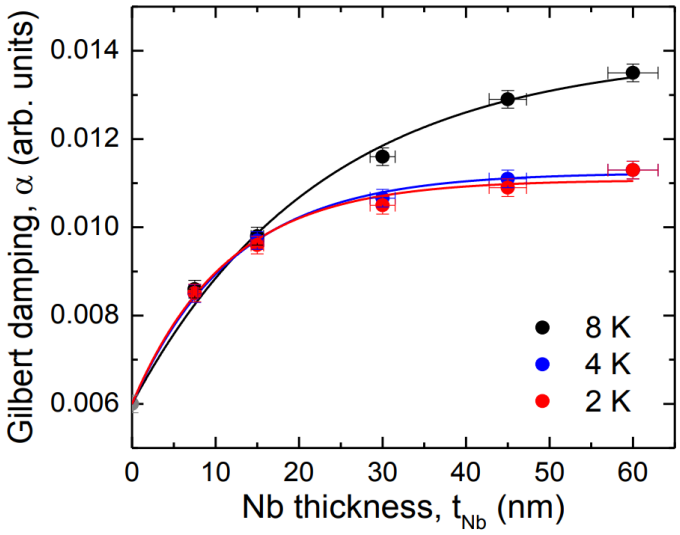
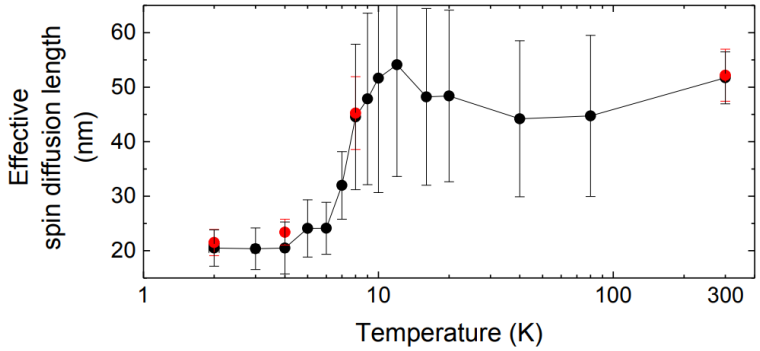
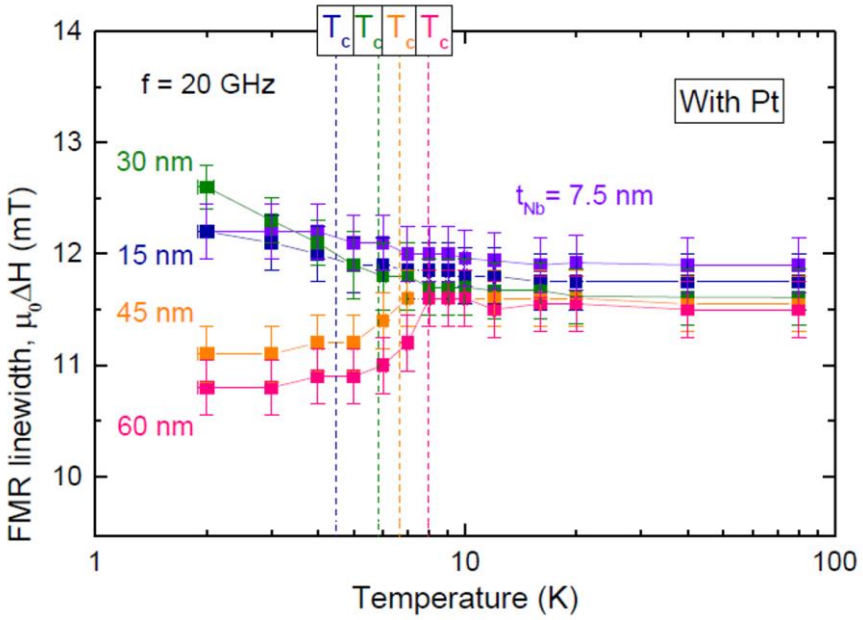




$$l_{QP}^{S} = \sqrt{D\left(\frac{1}{\tau_{AR}} + \frac{1}{\tau_s}\right)^{-1}} \sim 20 \text{ nm}$$



An unusual behavior is observed in the presence of Pt



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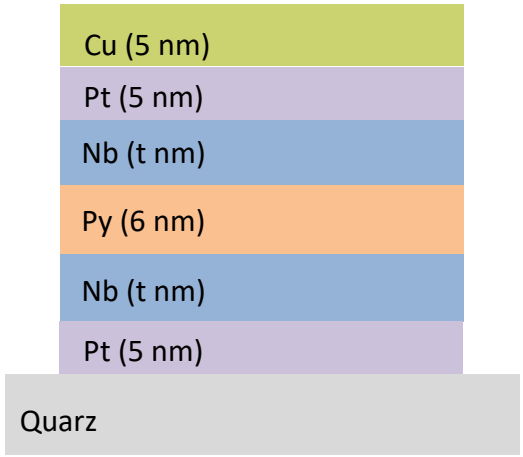

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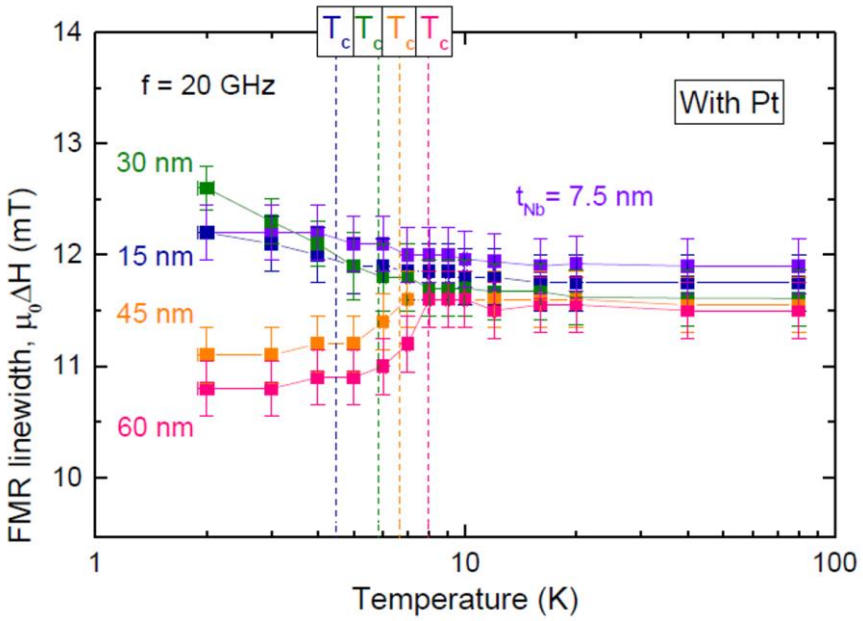
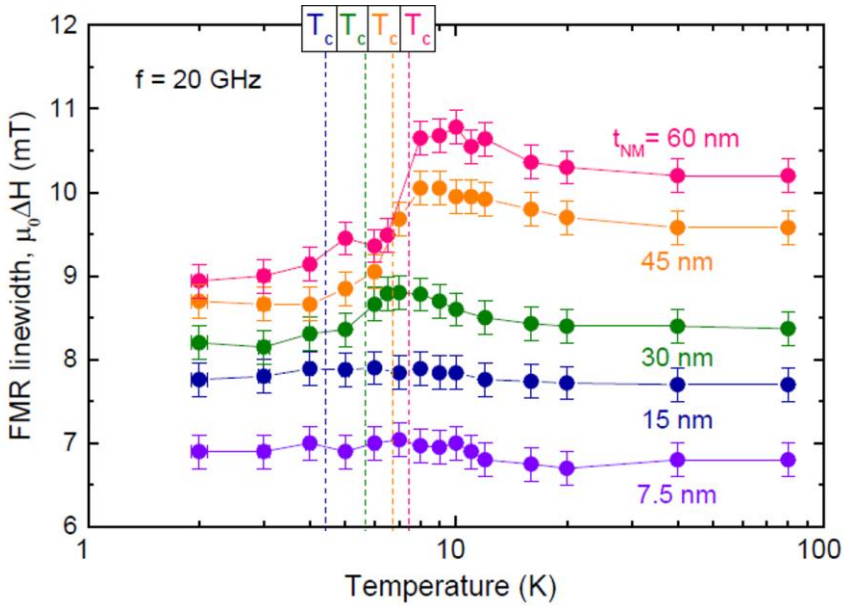
An unusual behavior is observed in the presence of Pt





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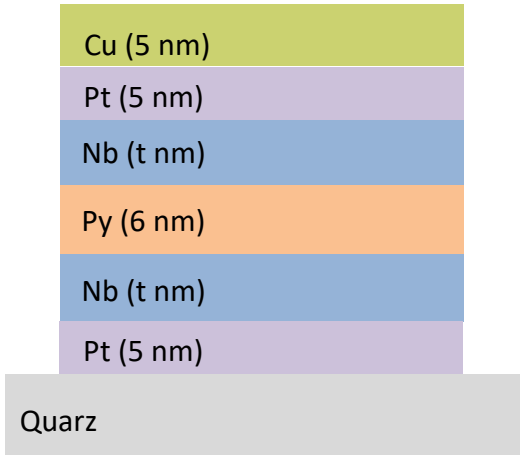

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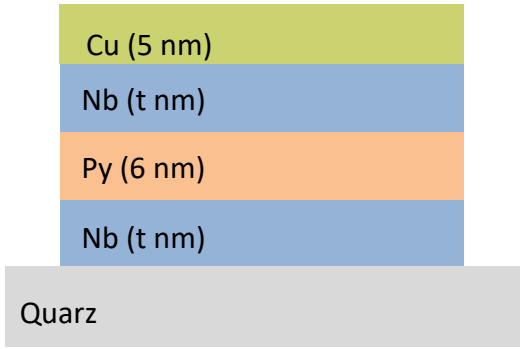

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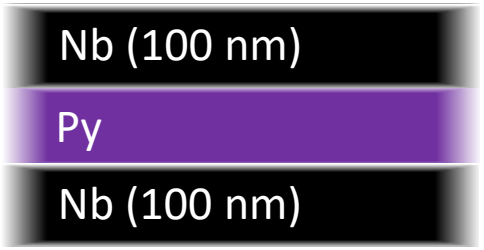
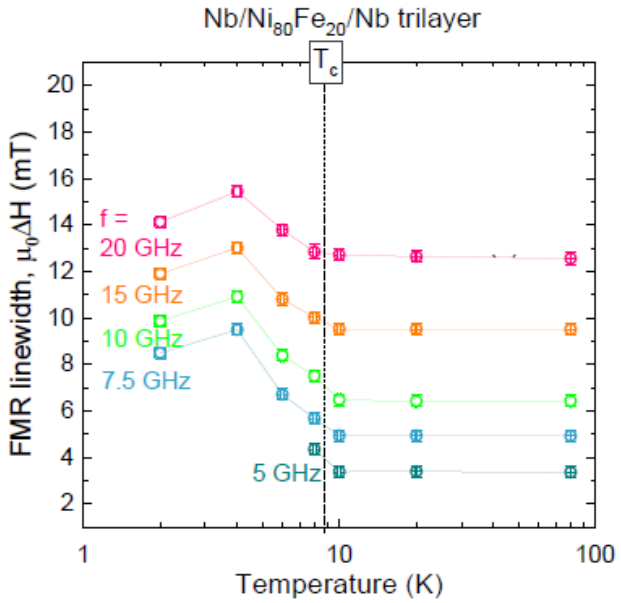
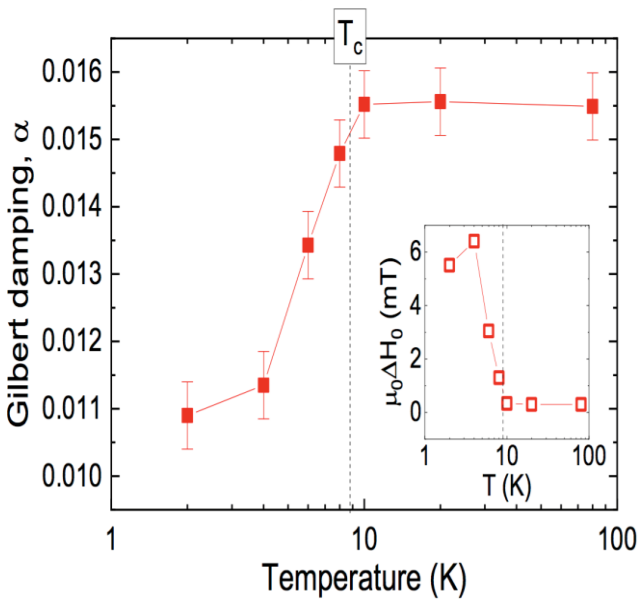
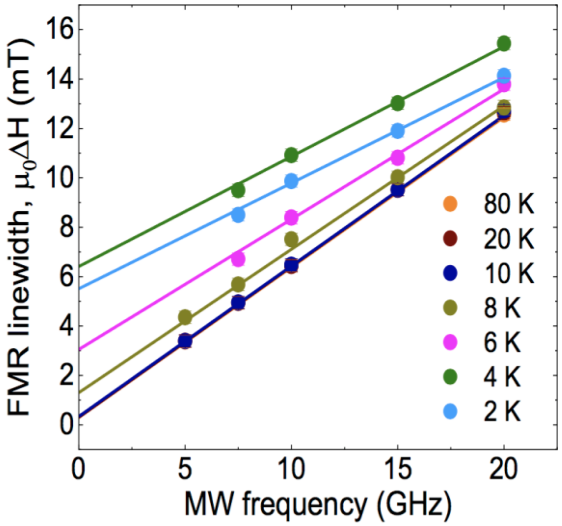
Meissner screening



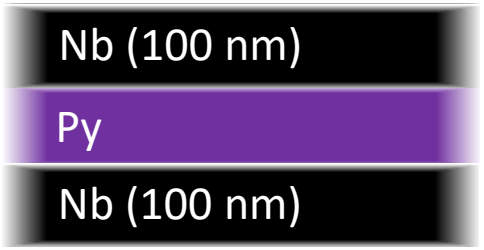


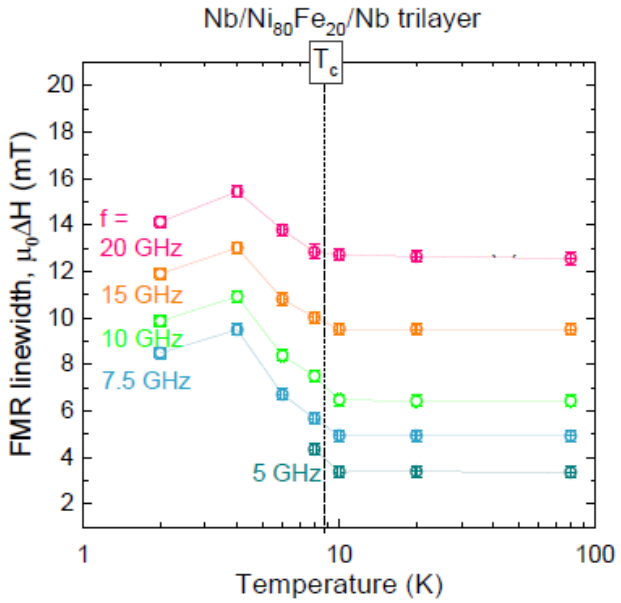


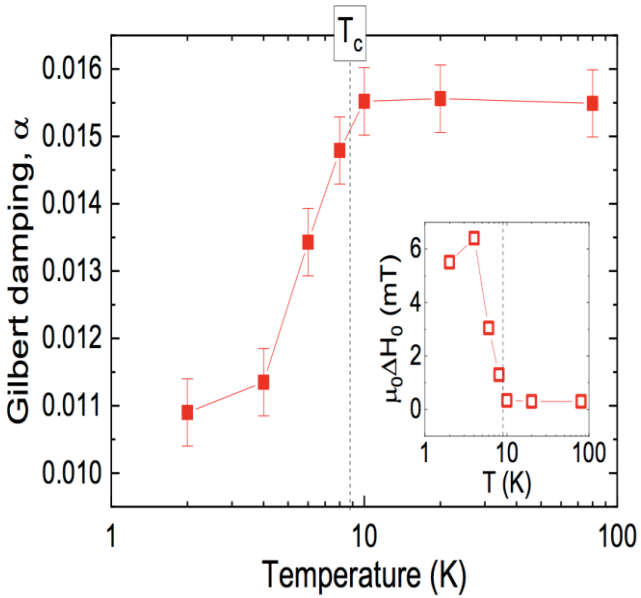


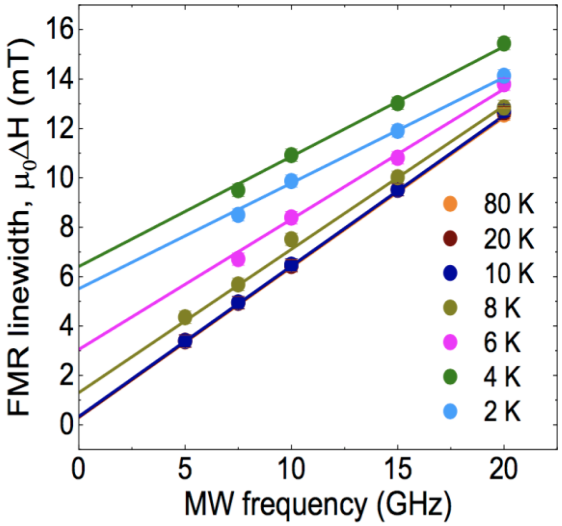
Phys. Rev. Appl., 11, 014061

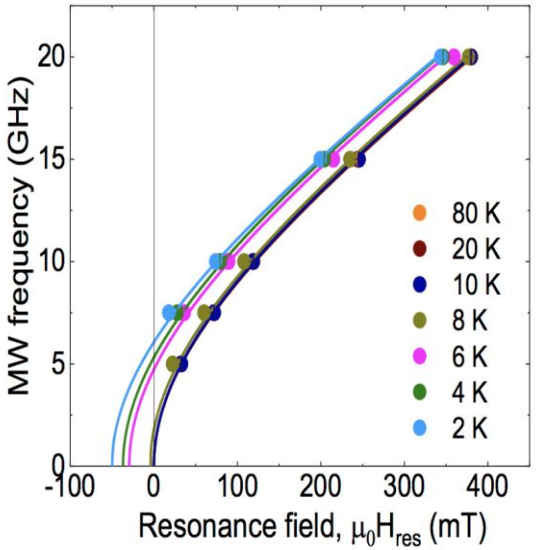
Meissner screening







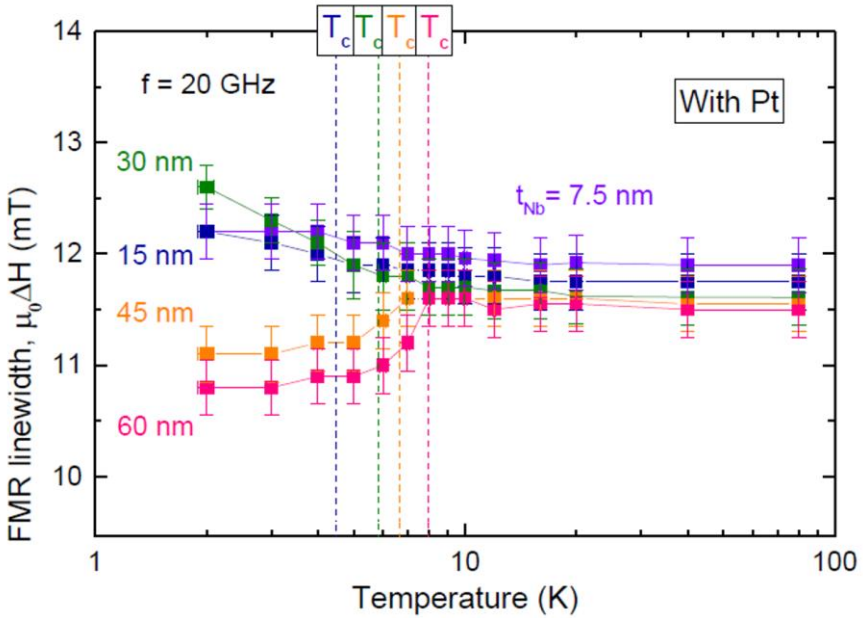


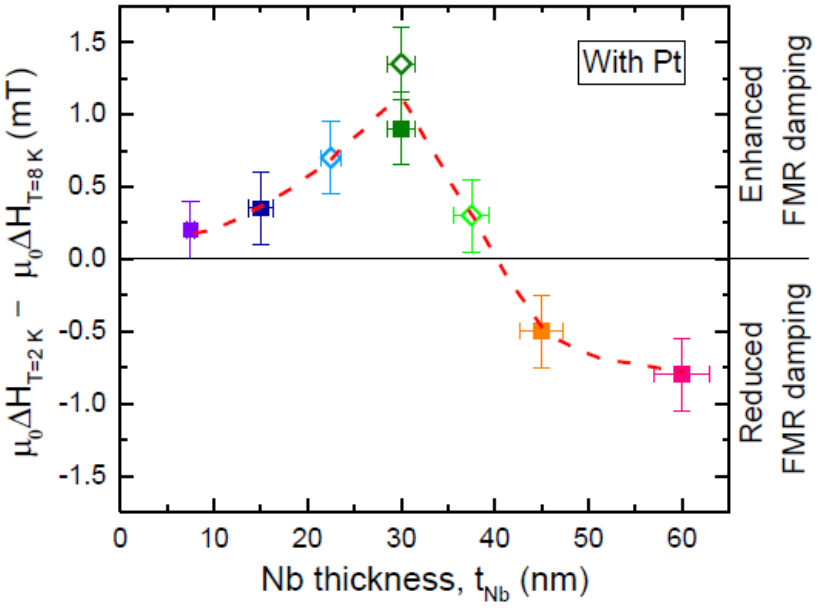


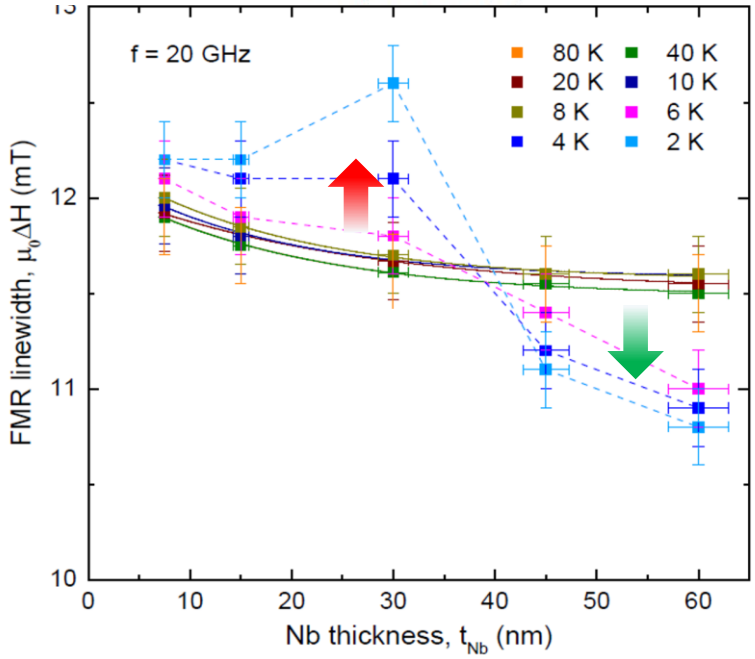
$$f = \frac{\gamma}{2\pi}\sqrt{\mu_0(H_{res} + M_{eff} + \Delta H) \cdot \mu_0(H_{res} + \Delta H)}$$

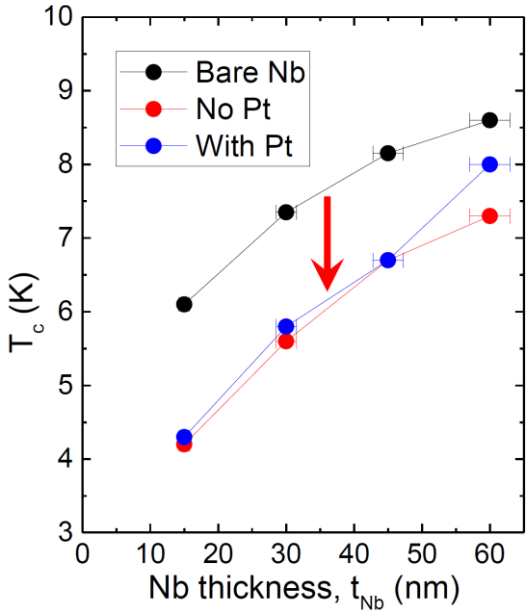
Phys. Rev. Appl., 11, 014061

An unusual behavior is observed in the presence of Pt

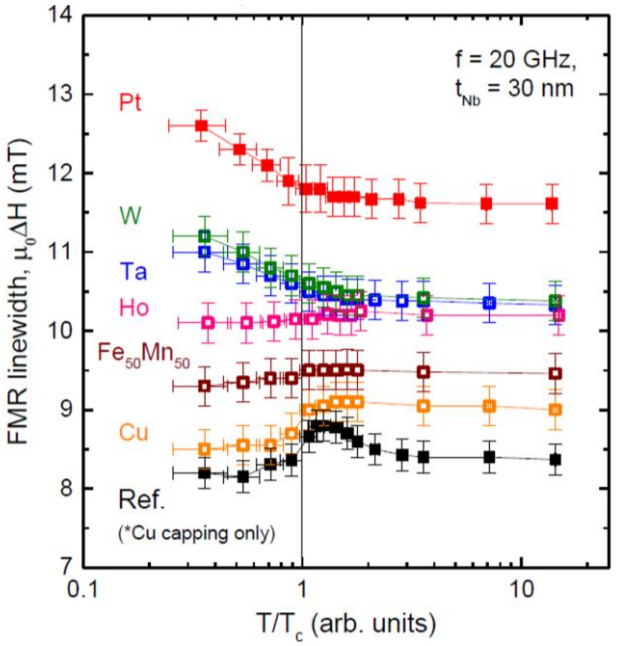


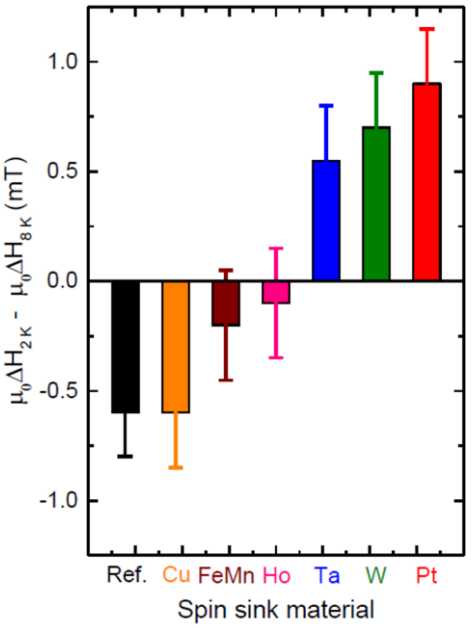






We substitute Pt with different metals





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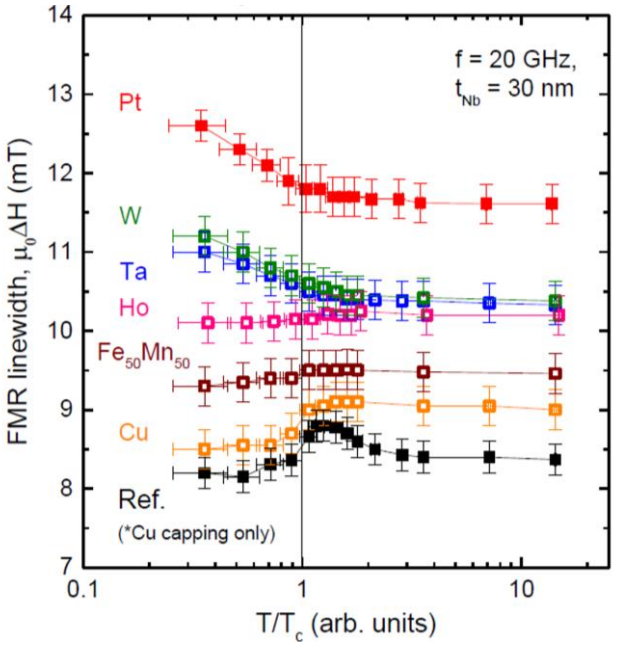
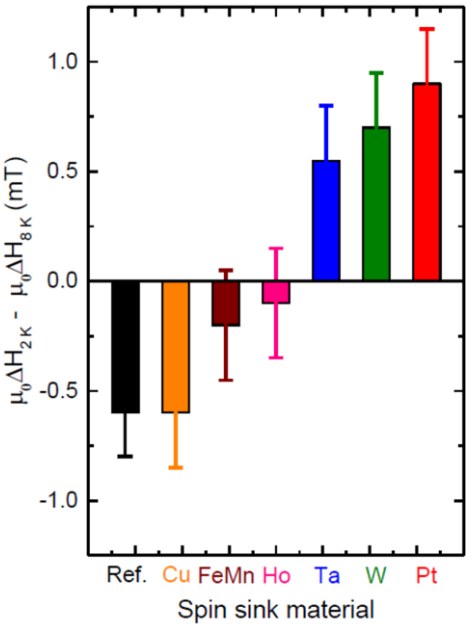
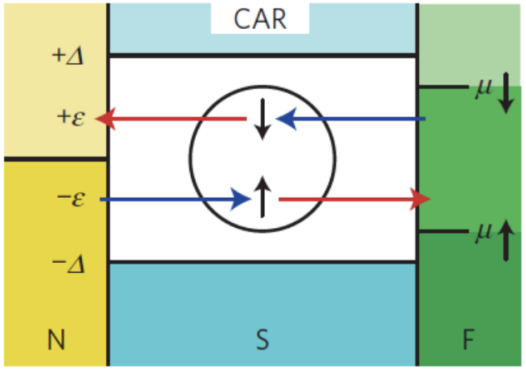
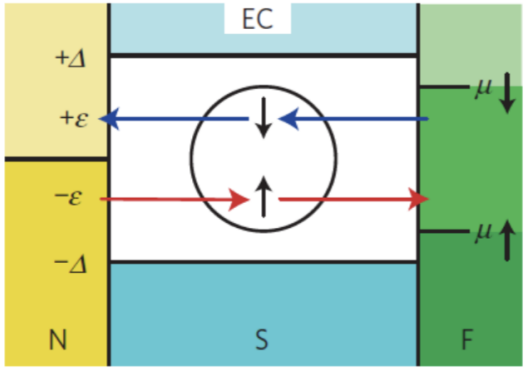
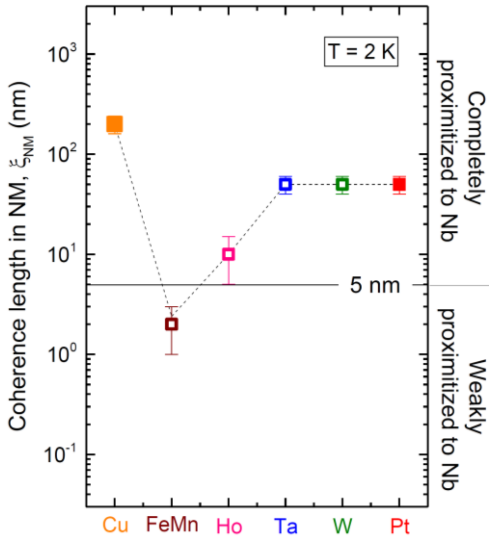




Quasiparticles-mediated spin-transfer

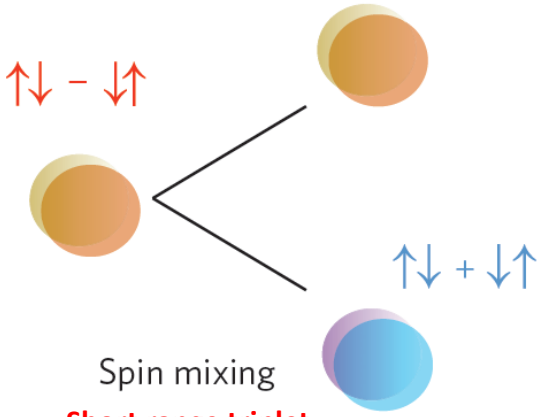






[Nature Phys. 12, 57 (2015)]
[Nature Phys. 9, 84 (2013)]

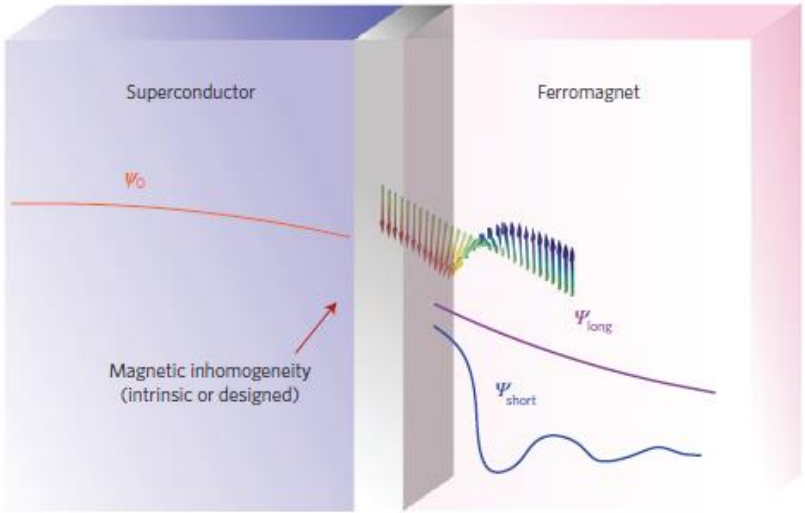
The role of Cooper pairs in mediating spin transport in Nb



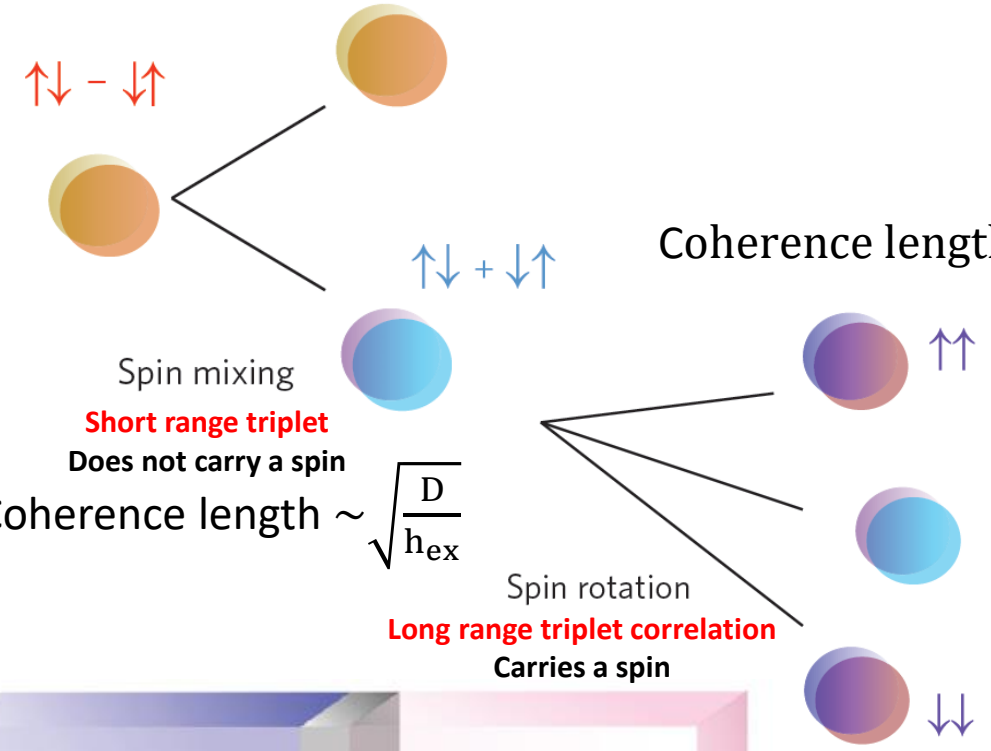
Short range triplet

Does not carry a spin

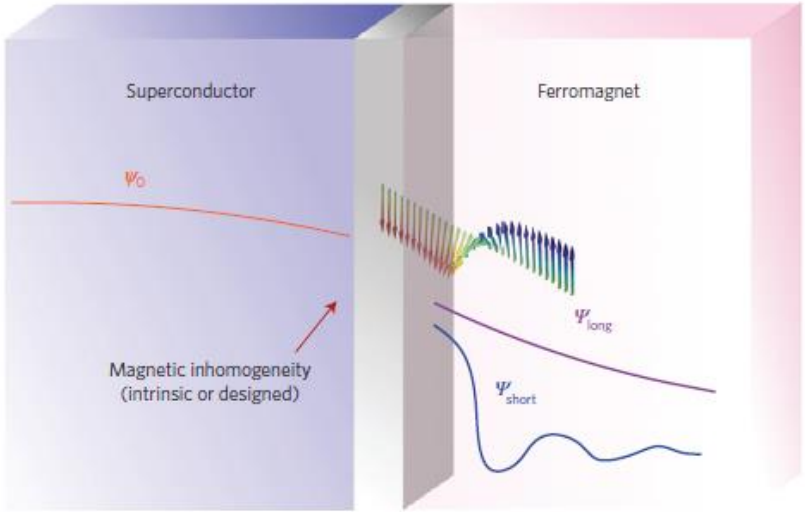
Coherence length $\sim \sqrt{\frac{D}{h_{ex}}}$



The role of Cooper pairs in mediating spin transport in Nb

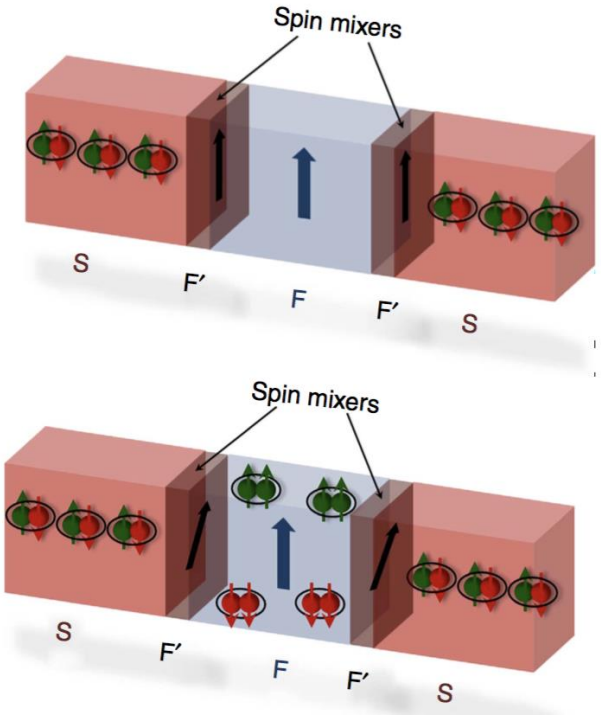


Coherence length ~ $\sqrt{\frac{D}{KT}}$

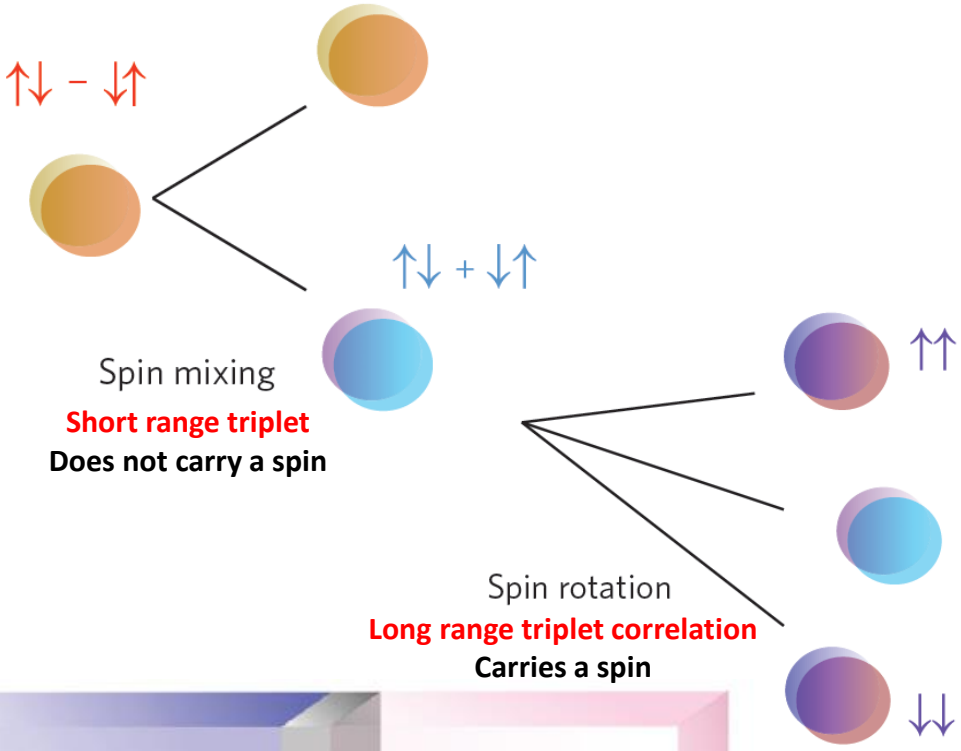


Science 329, 59 (2010)
Nature Commun. 5 4771 (2014)
Phys. Rev. Lett. 104 137002 (2010)
Sci Rep 2 699 (2012).
Phys. Rev. B 89 104505 (2014)

Physical Review X 5 021019 (2015).
Phys. Rev. Lett. 109, 057005 (2012)

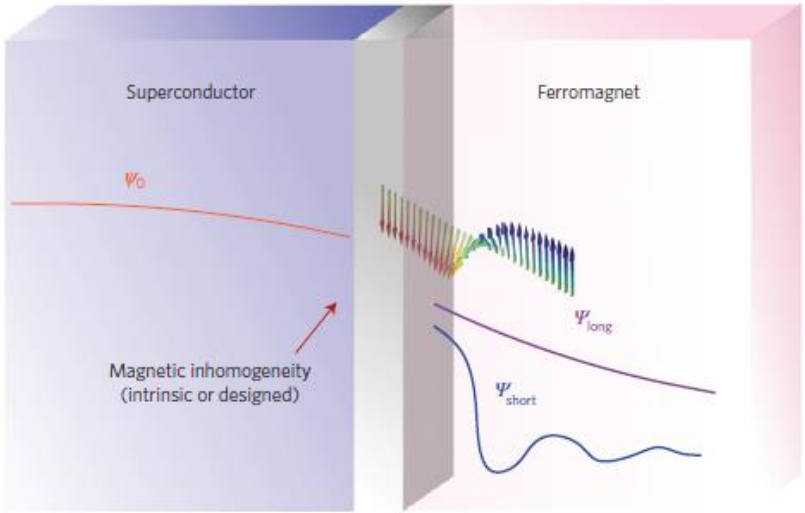


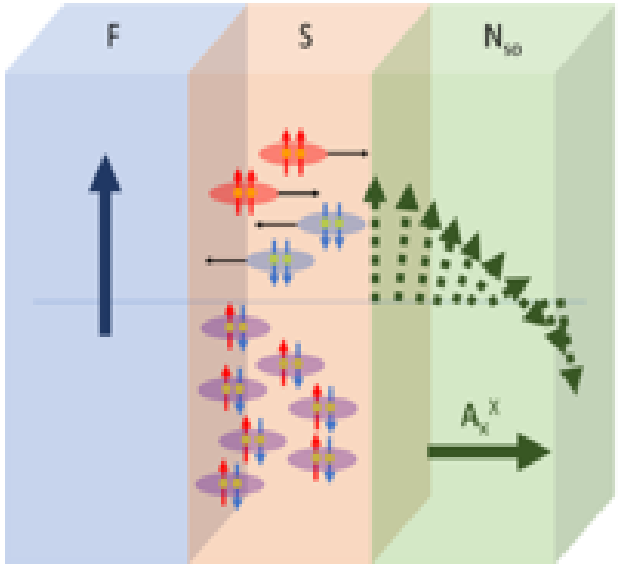
The role of Cooper pairs in mediating spin transport in Nb



Pt, Ta, W have two characteristics:

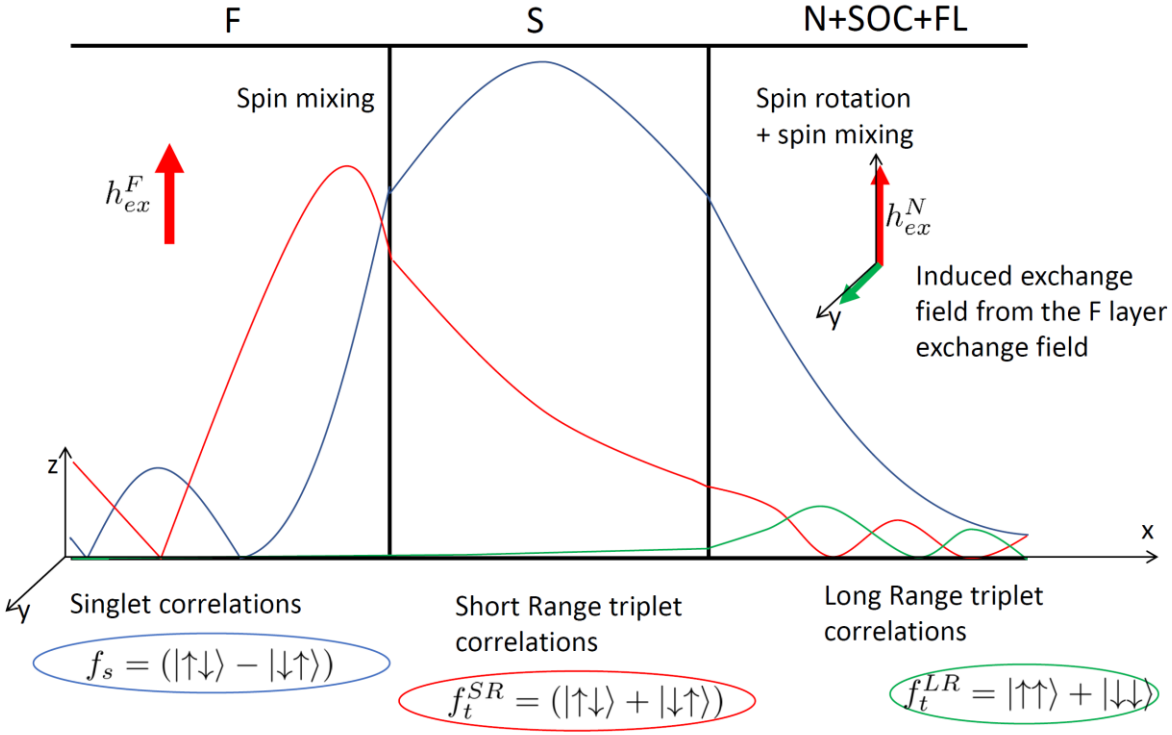
- Spin-orbit coupled
- Close to a ferromagnetic/ possible proximity magnetism

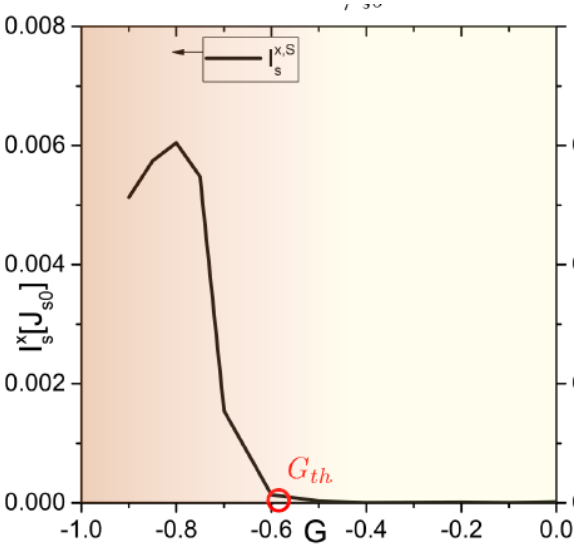




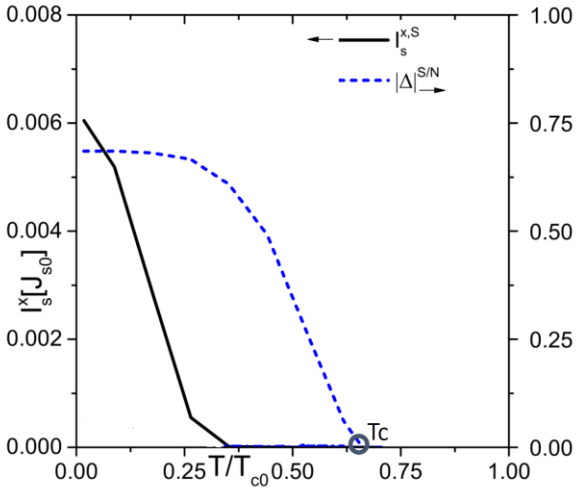
Phys. Rev. B 98, 104513 (2018)

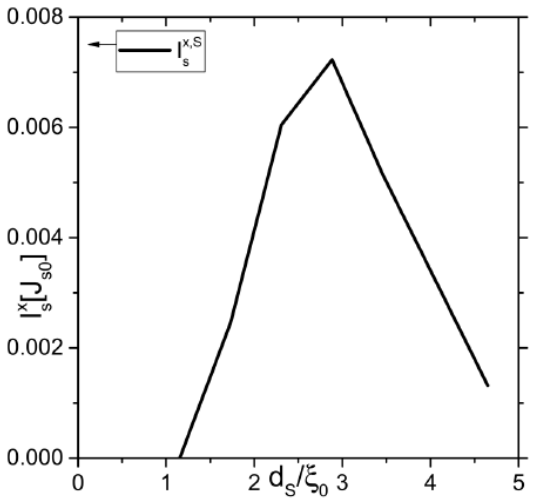
The role of Cooper pairs in mediating spin transport in Nb



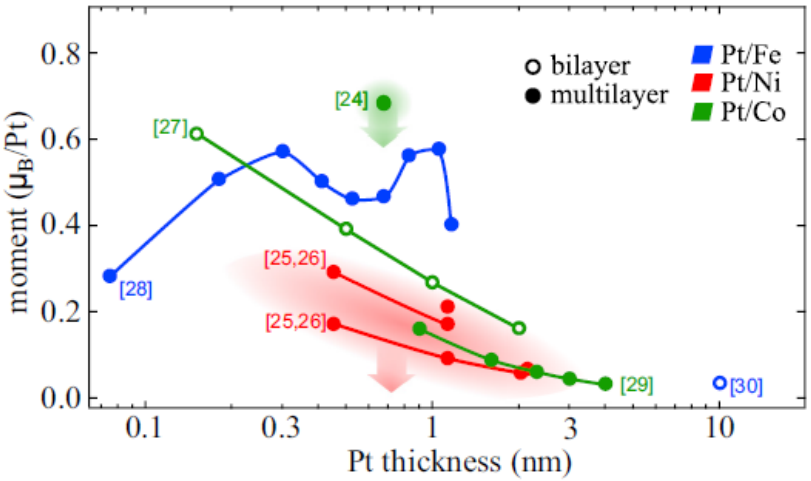


[Phys. Rev. B 98, 104513 (2018)]

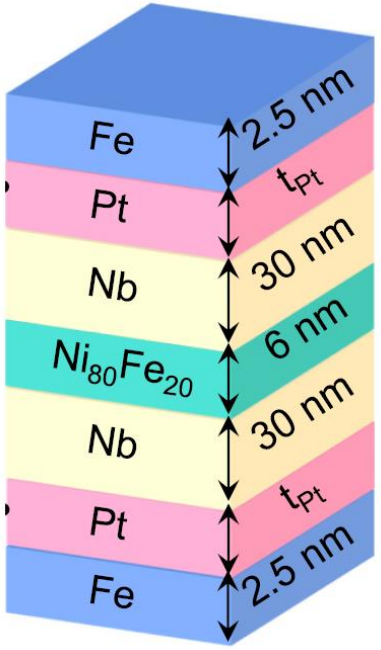


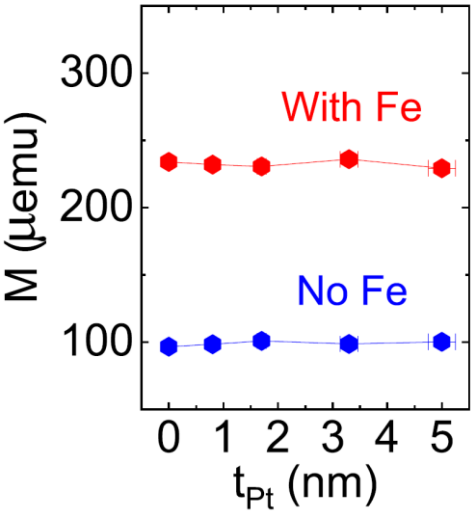


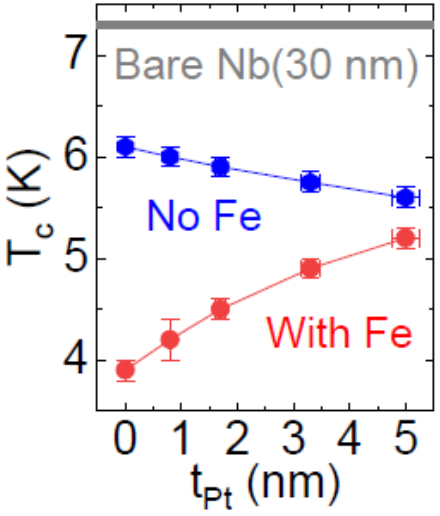
The role of the exchange in Pt

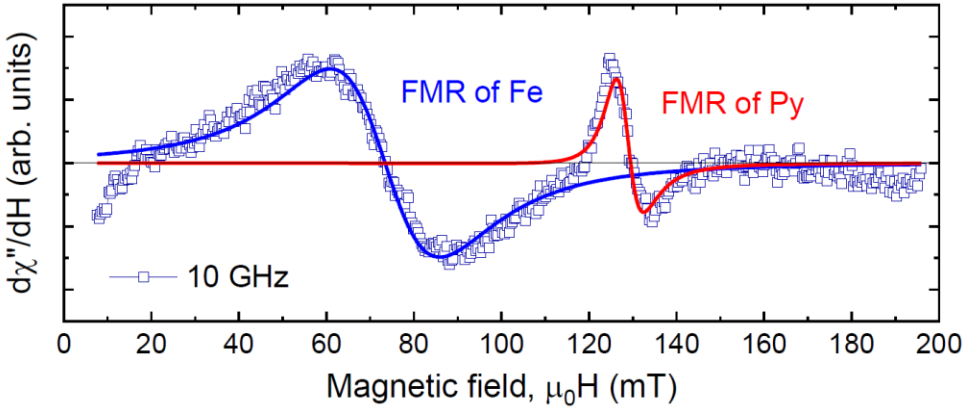


PRB **93**, 214440 (2016)



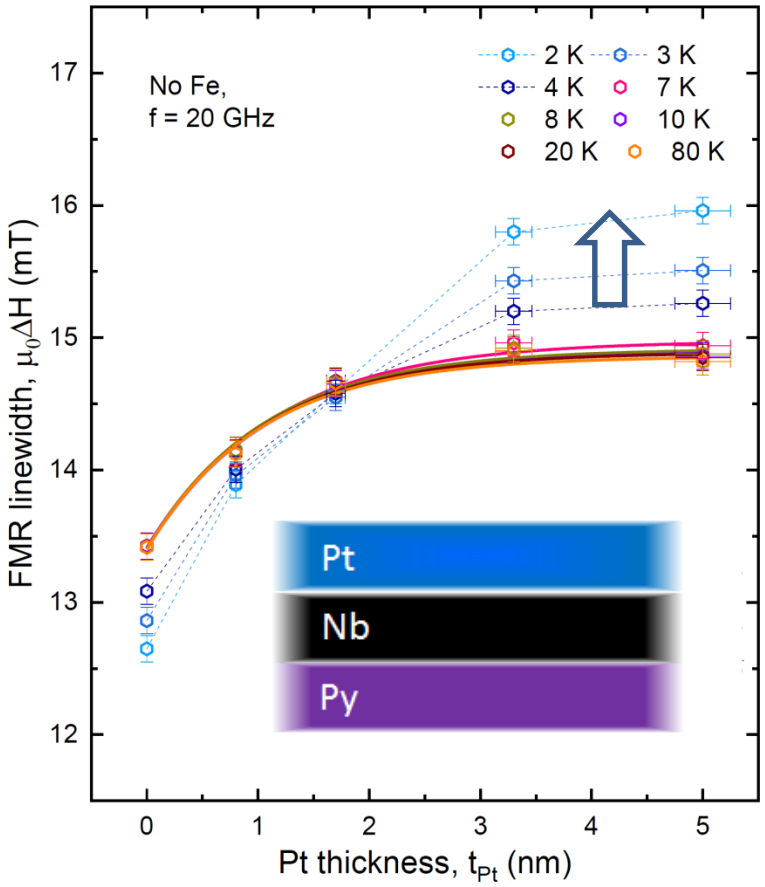


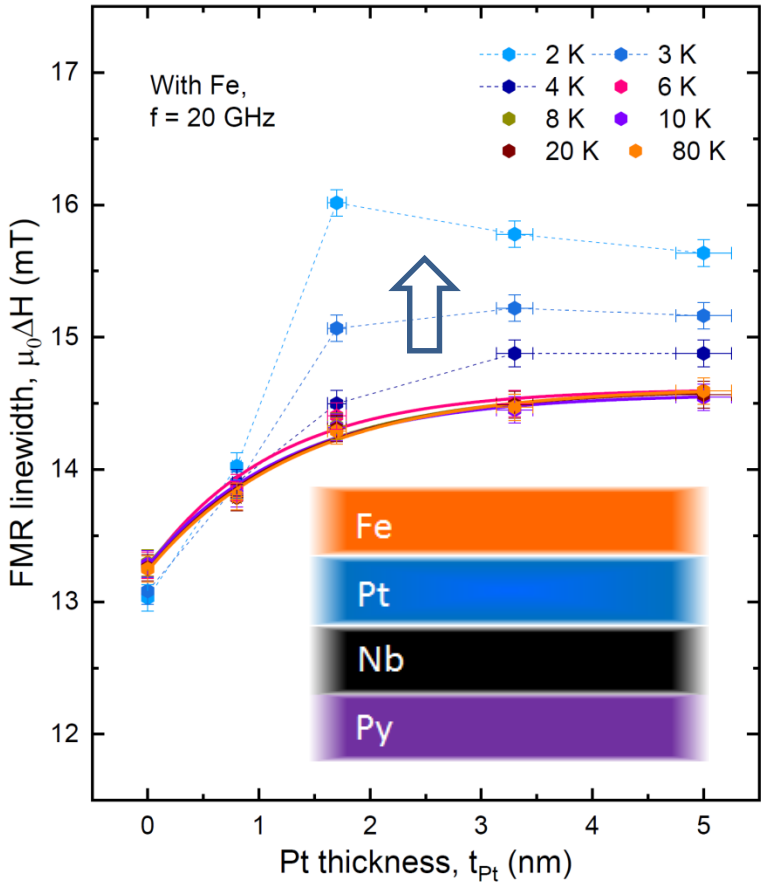




Phys. Rev. B 99, 024507 (2019)

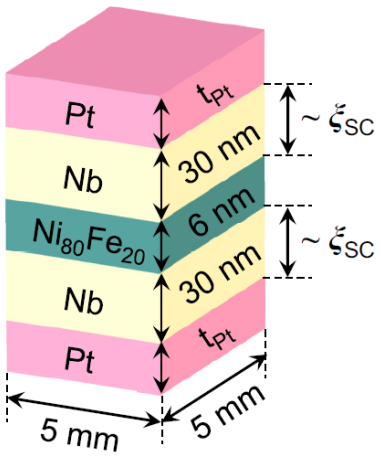
The role of the exchange in Pt

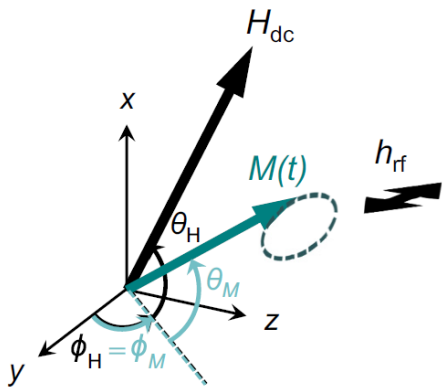


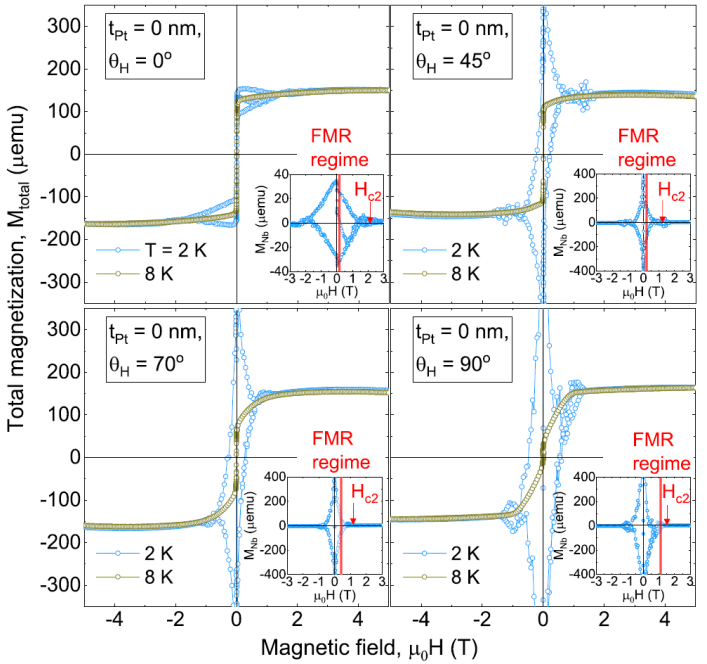


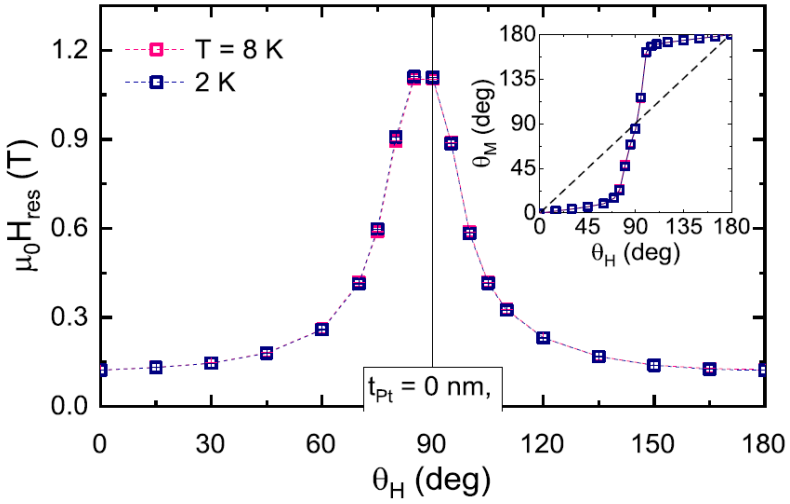
Phys. Rev. B 99, 024507 (2019)

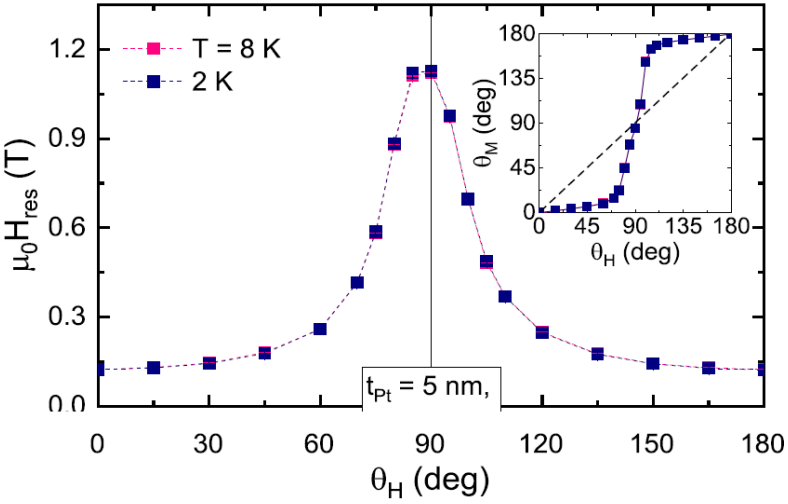
Abrikosov vortex nucleation effecr in an OP field





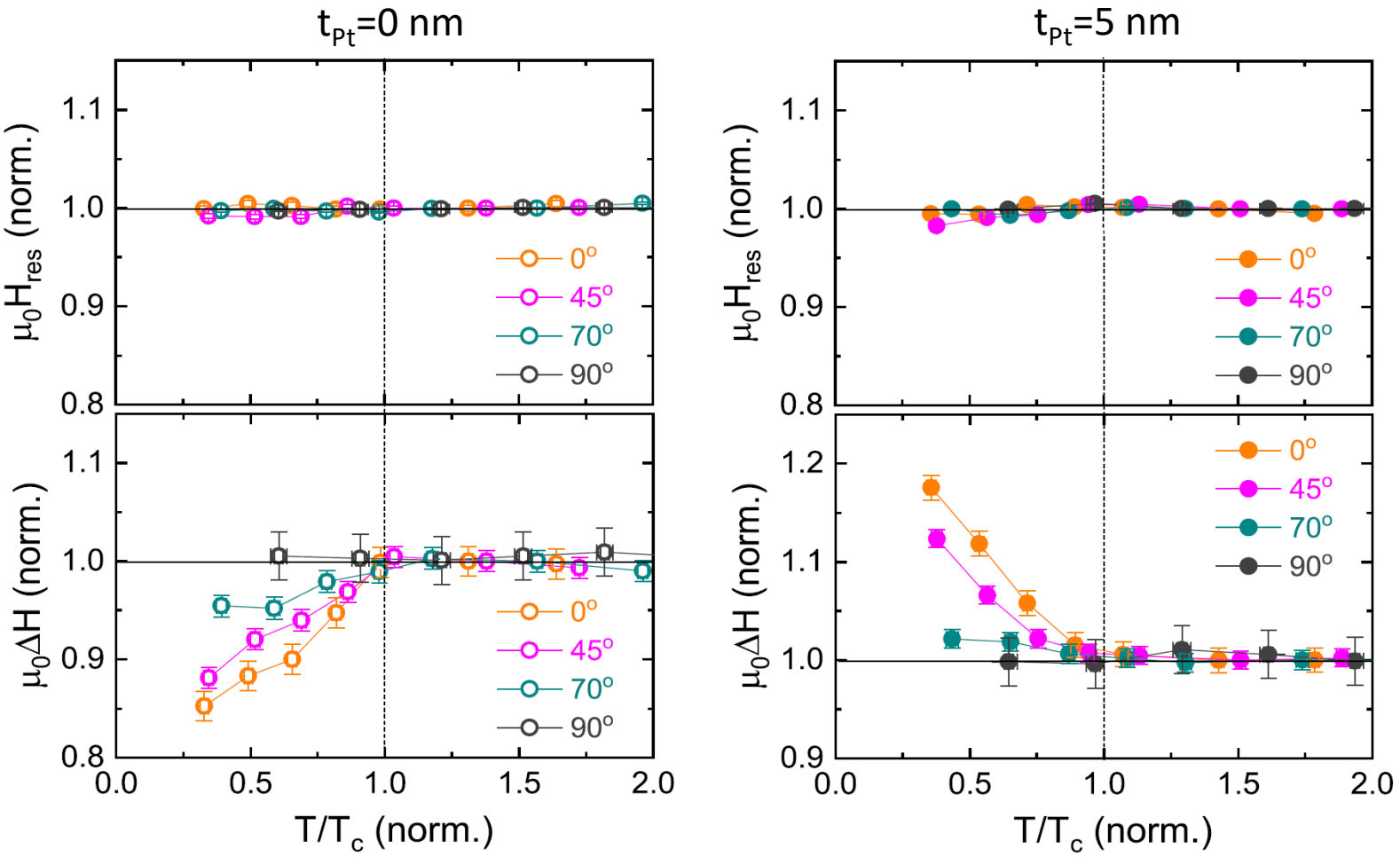






Phys. Rev. B 99, 144503 (2019)

Abrikosov vortex nucleation effecr in an OP field



Phys. Rev. B 99, 144503 (2019)

Conclusions

- In spin pumping superconducting Nb can be a better spin sink than Pt
- The spin pumping efficiency is increased when Nb is interfaced by a high SO coupling paramagnet
- Enhancement of the exchange field within the paramagnet leads to a further increase of the spin pumping

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Phys. Rev. X 10, 031020 (2020)
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