



GHOST

group of high resolution optical spectroscopy and related techniques

website: <http://ghost.fisica.unipg.it/>



Nanomagnetism Group

STAFF

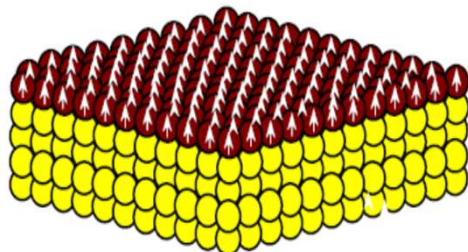
Dr. Gianluca Gubbiotti, CNR-IOM gubbiotti@iom.cnr.it

Prof. Giovanni Carlotti, Dipartimento di Fisica e Geologia

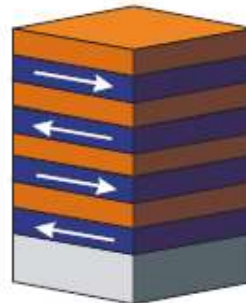
Prof. Marco Madami, Dipartimento di Fisica e Geologia

Dr. Silvia Tacchi, CNR-IOM

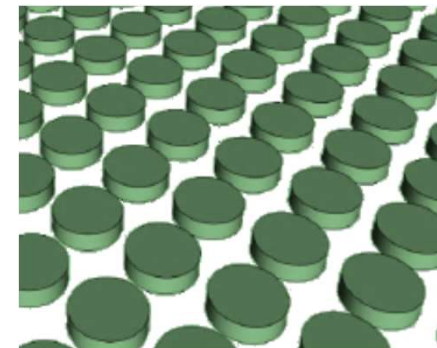
Magnetic films



Multilayers



Lateral structures



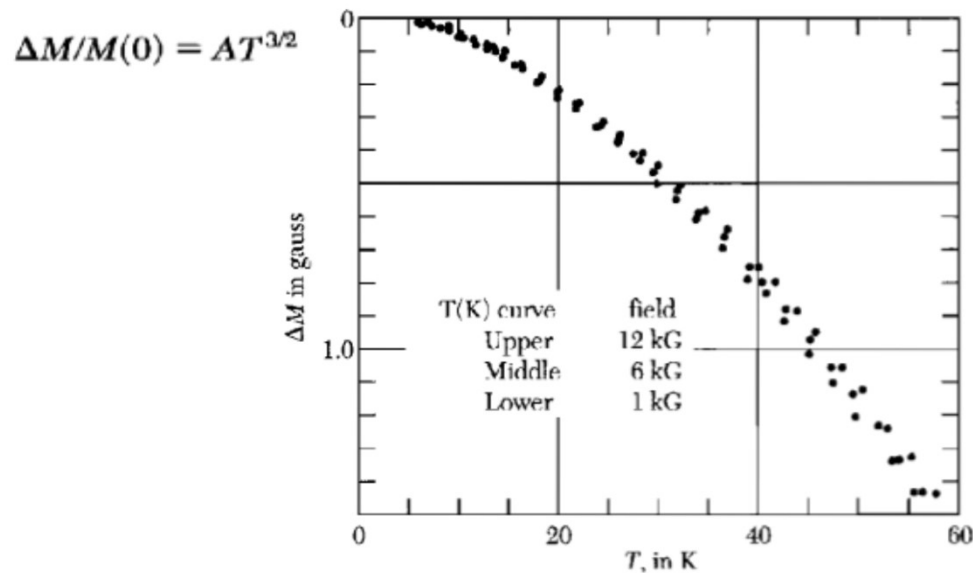
Onde di spin (Magnoni)

Zur Theorie des Ferromagnetismus.

Von **F. Bloch**, zurzeit in Utrecht.

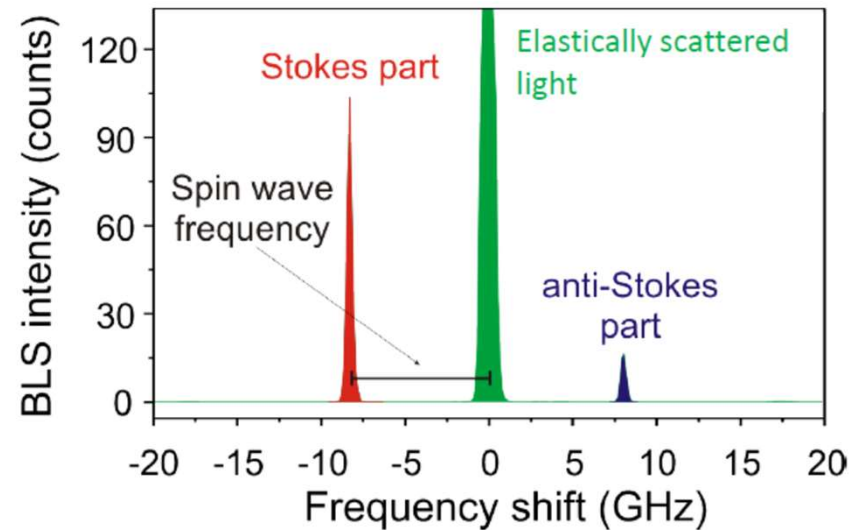
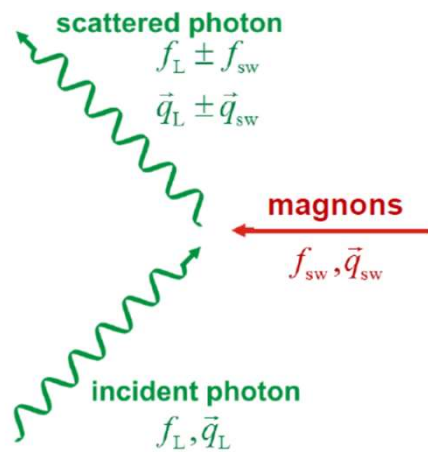
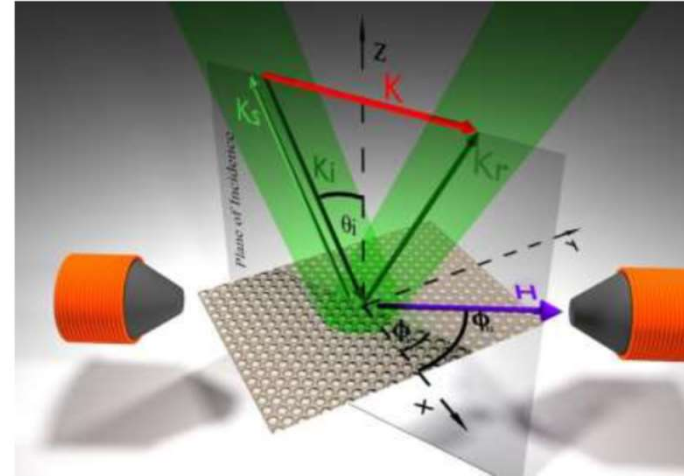
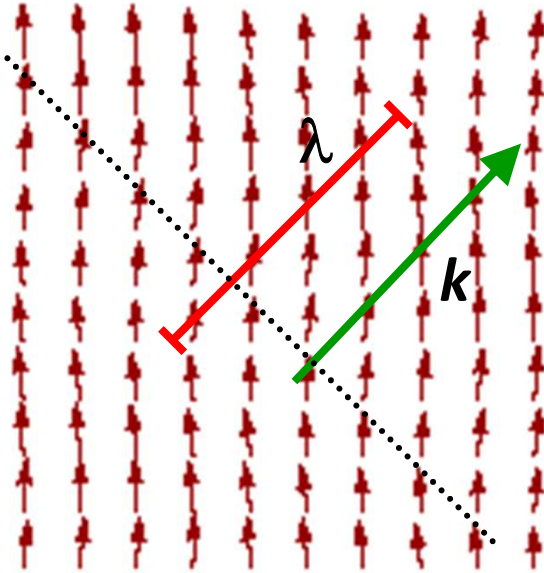
(Eingegangen am 1. Februar 1930.)

Beim Austauschvorgang der Elektronen im Kristall werden die Eigenfunktionen nullter und Eigenwerte erster Näherung für die Termsysteme hoher Multiplizität bestimmt, wobei die Kopplung zwischen Spin und Bahn vernachlässigt wird. Sie gestatten, das ferromagnetische Verhalten bei tiefen Temperaturen zu untersuchen und insbesondere die Frage zu beantworten, unter welchen Bedingungen Ferromagnetismus überhaupt möglich ist. Es zeigt sich, daß dies nur für räumliche Gitter der Fall ist; die Sättigungsmagnetisierung hat dann für tiefe Temperaturen die Form $M(T) = M(0) [1 - (T/\Theta)^{3/2}]$.



Onde di Spin in film ferromagnetici e Spettroscopia Brillouin

Wave front

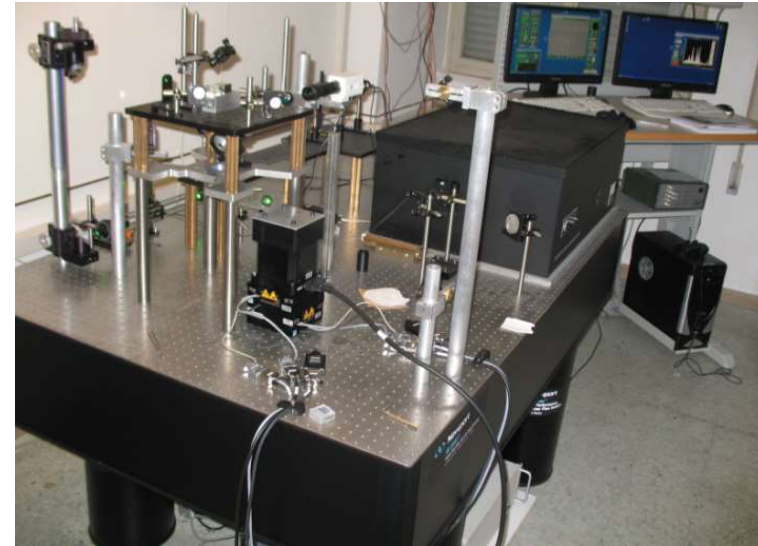


I nostri strumenti di indagine:

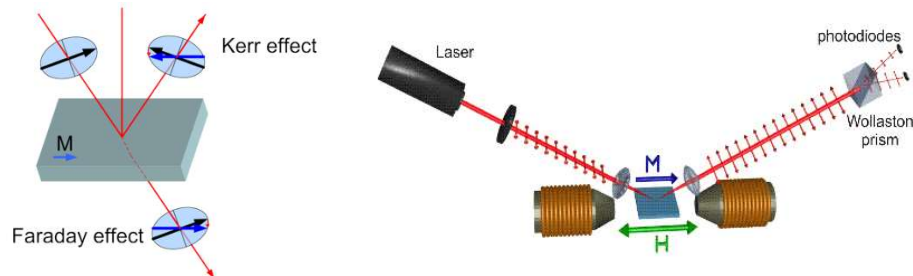
Brillouin Light Scattering (BLS) -Spettroscopia



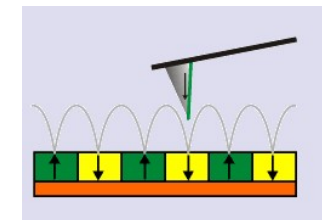
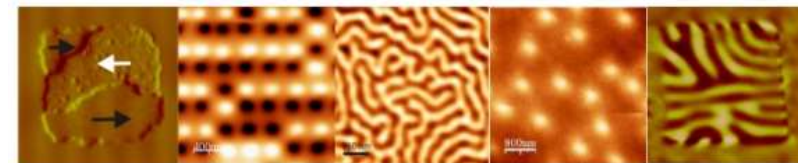
BLS-Microscopia



Magneto-Optic Kerr Effect (MOKE)



Magnetic Force Microscopy (MFM)



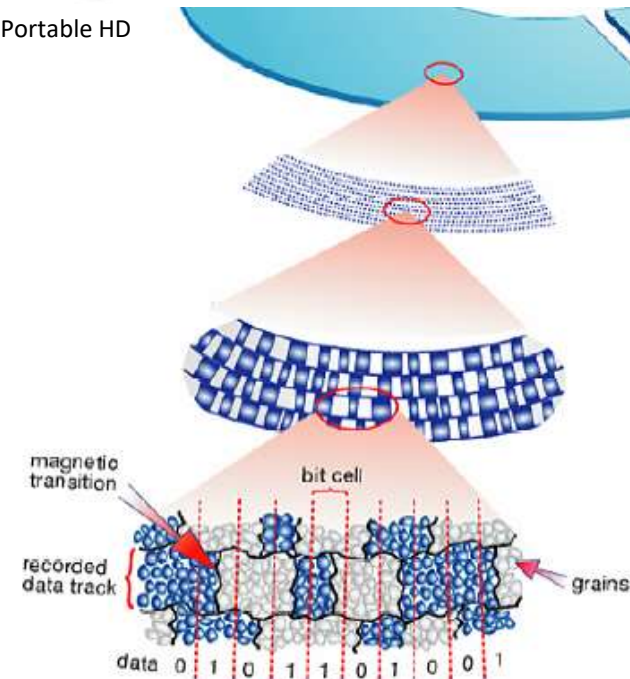
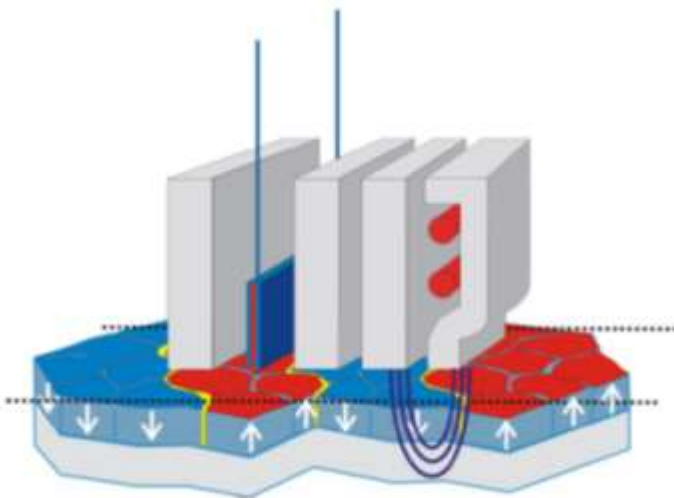
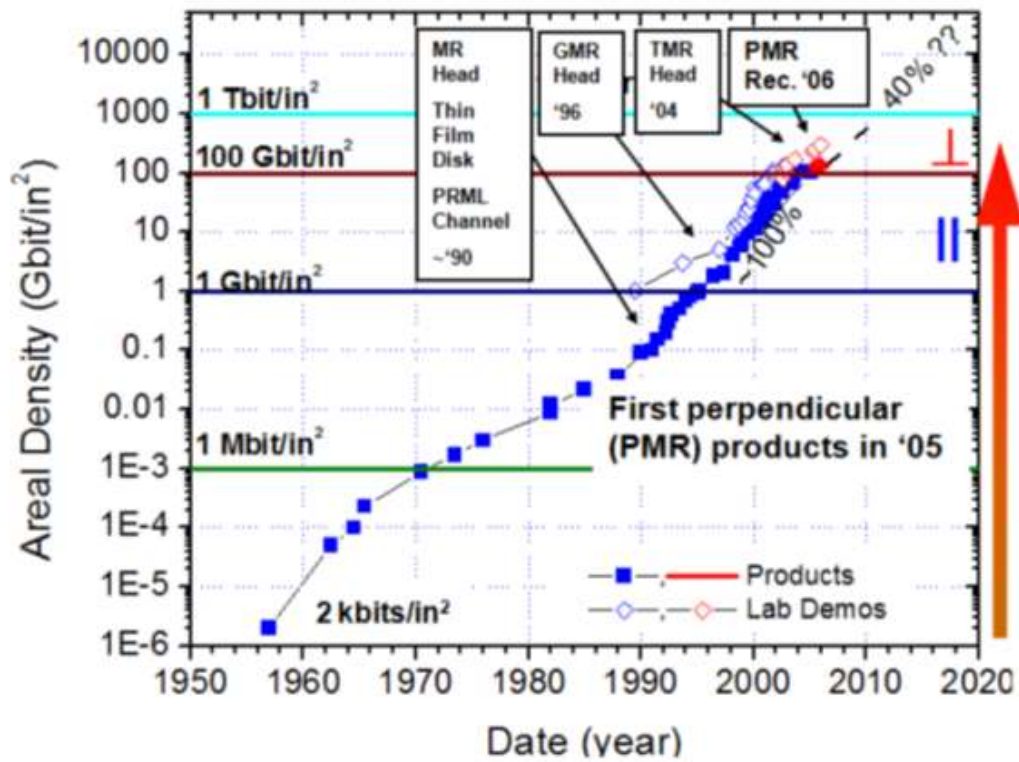
Micromagnetic simulations:

OOMMF

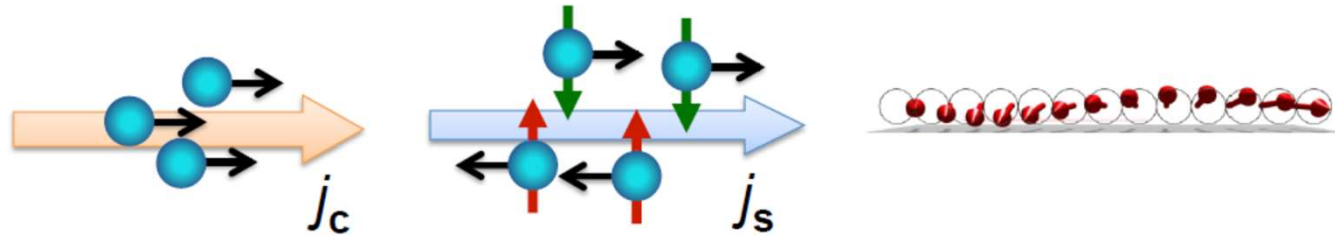
Micromagus

Mumax3 (GPUs, Nvidia CUDA®)

Magnetic Recording



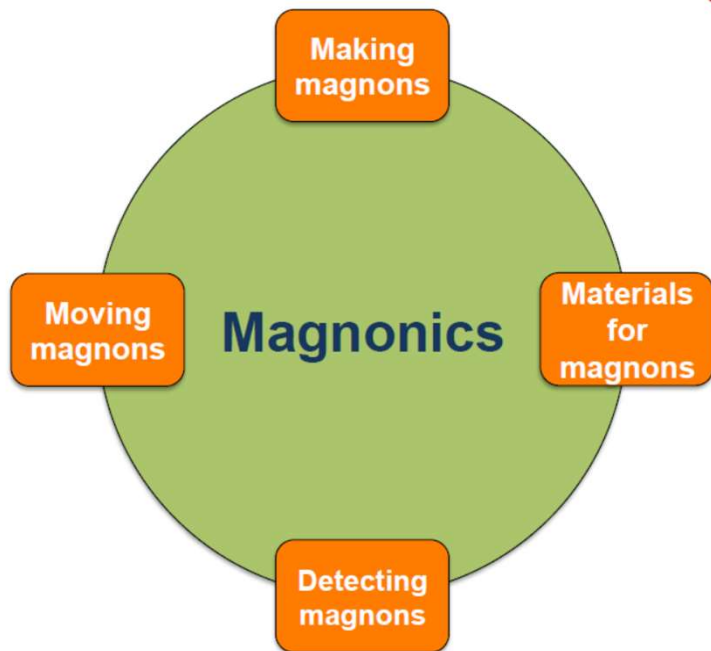
Magnonics- Magnon Spintronics



Electronics	Spintronics	Magnonics
Carrier of information: charge of electron	Carrier of information: spin of electron	Carrier of information: magnon

- ❖ GMR (Nobel Prize in 2007)
- ❖ TMR
- ❖ STT
- ❖ ...

No flow of real particles!



Propagazione di Onde di Spin in presenza di interazione Dzyaloshinskii-Moriya

Exchange



Mutual alignment

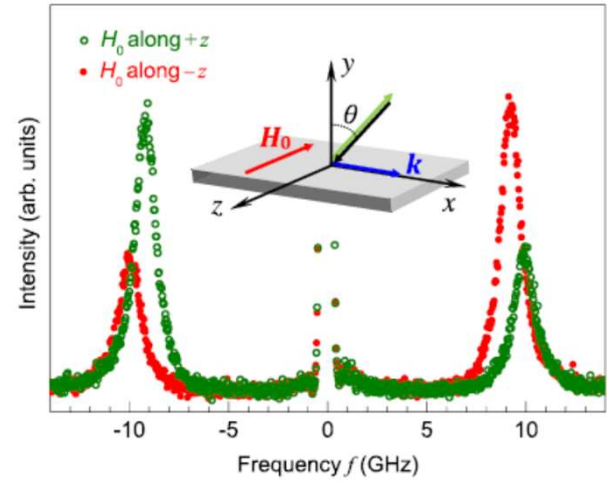
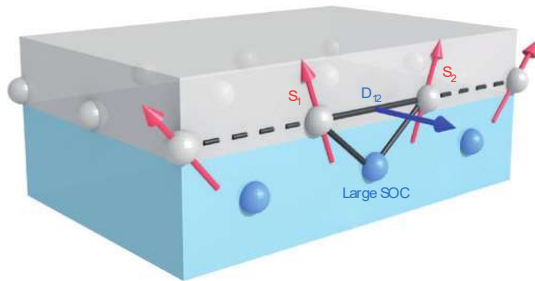
DMI



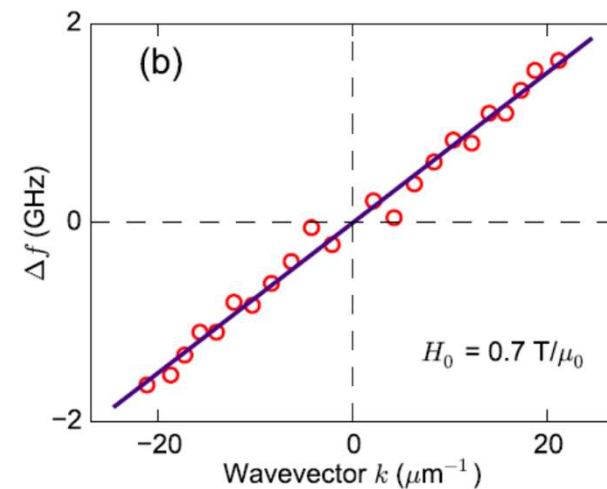
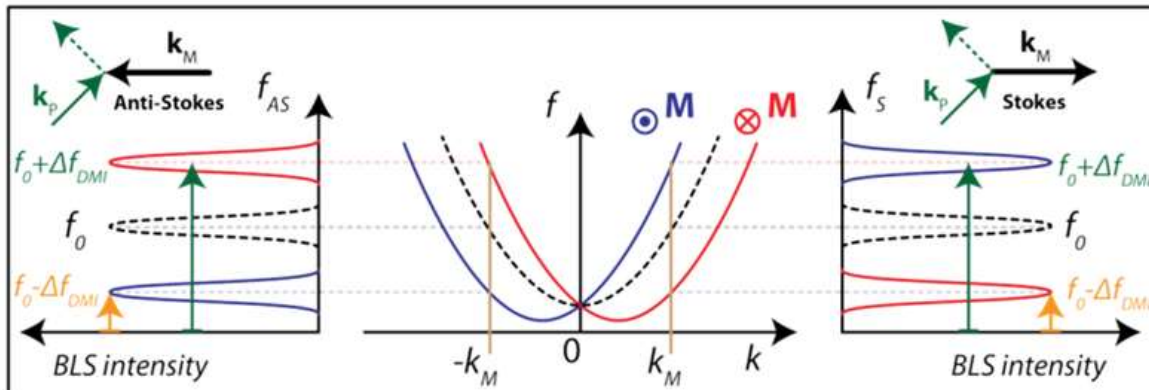
Spin canting (indirectly coupled)

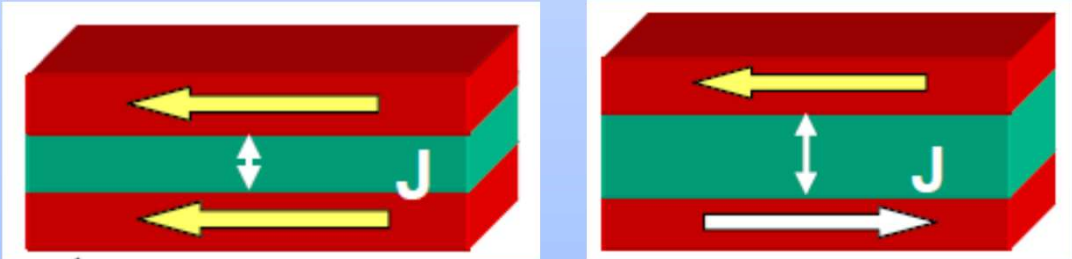
$$E_{bilinear} = - \sum_{ij} K_{ij} S_1^i S_2^j \quad E_{DM} = - \sum_{ij} D_{ij} (S_i \times S_j)$$

$$E = -JS^2 \cos \theta + DS^2 \sin \theta$$

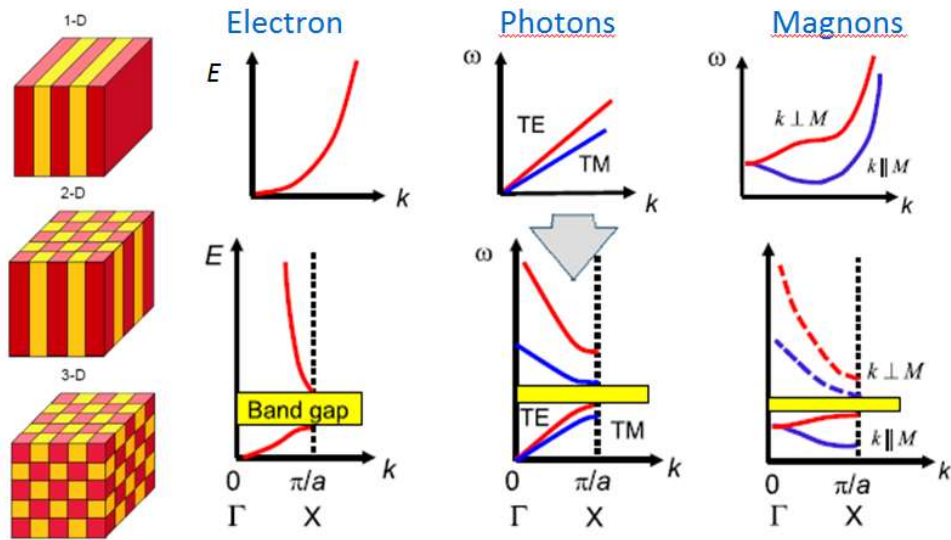


$$\Delta f(k) = f(-k) - f(k) = \frac{2\gamma}{\pi M_S} Dk$$

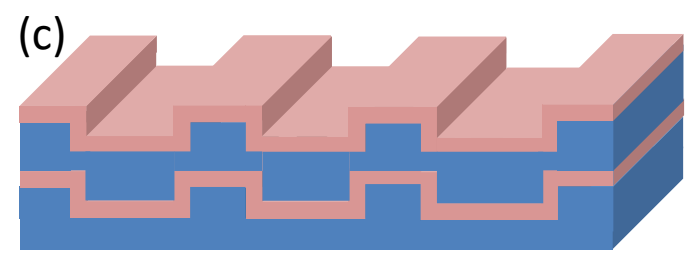
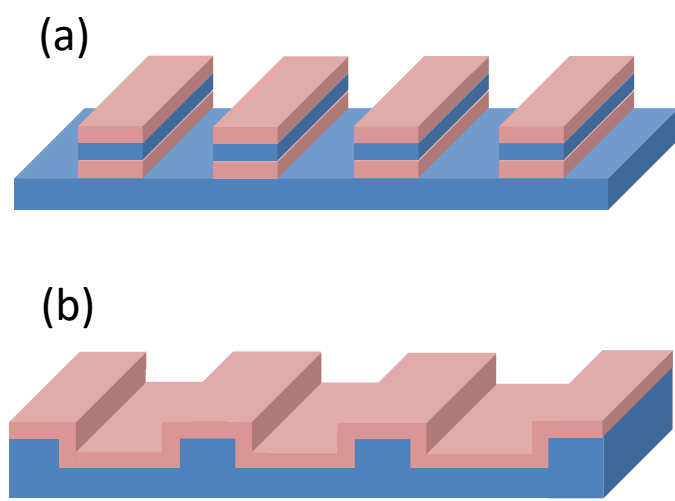
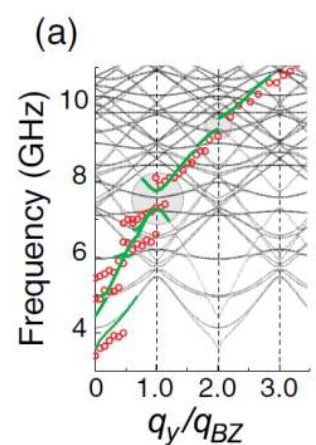
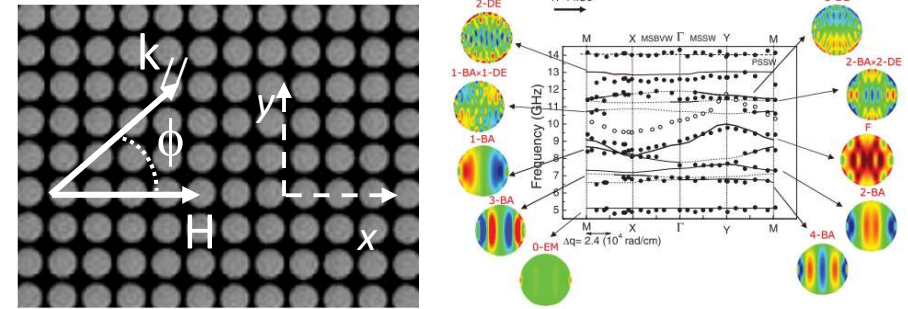


Argomento	Propagazione di onde di spin in eterostrutture - ferromagnetico/metallo pesante -isolante topologico (Triennale/Magistrale)
Tipo	Sperimentale (BLS)
Descrizione	Misura dell'interazione <u>Dzyaloshinskii-Moriya</u> (DMI) in film ferromagnetici sottili.
Collaborazioni	<ul style="list-style-type: none"> • Technical University of Munich (TUM)- (Germania) • Istituto Microelettronica e Microsistemi (IMM-CNR)- Agrate Brianza
Referente	Dr. Gianluca Gubbiotti
Sistemi studiati Pt\Co\W\Co Sb ₂ Te ₃ \Fe	

Cristalli Magnonici: modulazione periodica delle proprietà magnetiche



2D: Matrici bi-dimensionali di **dots** e **antidots**



■ Non magnetic layer
■ Ferromagnetic layer

Argomento	Studio della propagazione di onde di spin in cristalli magnonici tridimensionali (Triennale)
Tipo	Sperimentale (BLS) – Simulazioni micromagnetiche
Descrizione	Misura della <u>struttura a bande</u> in cristalli magnonici 3D. Comprensione dei fattori (geometrici) che determinano la formazione delle band gap.
Collaborazioni	IMEC-Leuven (Belgio)
Referente	Dr. Gianluca Gubbiotti
<p>Sistemi studiati</p> <p>Film di CoFeB depositati sulla superficie corrugata del Si</p>	