Xiu-Feng Han (韓秀峰)

Institute of Physics, Chinese Academy of Sciences
Beijing 100190,China
Tel: +86-10-8264-9268
E-mail: xfhan@iphy.ac.cn
Website: http://maglab.iphy.ac.cn/M02_Webpage/index.htm

Education:

1980-1984: B. Sc., Department of Physics, Lanzhou University
1987-1993: M. Sc & Ph. D., Department of Physics, Jilin University

Professional Employment:

1994 – 1996:	Postdoctor, Institute of Physics, Chinese Academy of Sciences
1996 – 1997	Associate Professor, Institute of Semiconductors, Chinese Academy of Sciences
1998 – 2001:	Visiting scholar, Tohoku University (Japan), University of New Orleans (USA), and Trinity College Dublin (Ireland) etc.
2002–Present:	Professor, Institute of Physics, Chinese Academy of Sciences

Research interests:

His present main research field is Spintronics Materials, Physics, and Devices.

His specialties and research content include: (1) Magnon Valve, Magnon Junction, and Magnonics; (2) Magnetic tunnel junction (MTJ) and tunneling magnetoresistance (TMR) materials, physics and devices; (3) Spin-Orbit Torque effect, Spin Hall effect and spin Seebeck effect in magnetic heterostructures ; (4) Hybrid MTJs based on ferromagnetic, multiferroic, semiconductor and organic materials etc., and their spin transport properties; (5) New designed spintronic devices of Magnetic Random Access Memory (STT-MRAM, SOT-MRAM), TMR magnetic Sensors, Magnetic Logic & Spin Logic, Spin Nano-Oscillator, Spin Diode, Spin Transistor and Spin Field Effect Transistor, etc.

Selected Publications:

[1] *Fabrication of high-magnetoresistance tunnel junctions using $Co_{75}Fe_{25}$ ferromagnetic electrodes.*
X. F. Han, M. Oogane, H. Kubota, Y. Ando, and T. Miyazaki.
Appl. Phys. Lett. **77** (2000) 283.

[2] *First-principles theory of quantum well resonance in double barrier Magnetic Tunnel Junctions.*
Y. Wang, Z.Y. Lu, X.G. Zhang, and **X. F. Han***,
Phys. Rev. Lett. **97** (2006) 087210.

[3] *Probing spin flip scattering in ballistic nanosystems.*
Z. M. Zeng, J. F. Feng, Y. Wang, **X. F. Han***, W. S. Zhan, X. G. Zhang, and Z. Zhang.
Phys. Rev. Lett. **97** (2006) 106605.

[4] Patterned nanoring magnetic tunnel junctions.
Z. C. Wen, H. X. Wei, and **X. F. Han***
Appl. Phys. Lett. **91** (2007) 122511.

[5] Nanoring MTJ and its application in MRAM demo devices with spin-polarized current switching.
X. F. Han, Z. C. Wen, and H. X. Wei,
J. Appl. Phys. **103** (2008) 07E933 **(Invited paper**).

[6] *Long range phase coherence in double barrier MTJs with large thick metallic quantum well.*
B. S. Tao, H. X. Yang,Y. L. Zuo, X. Devaux, G. Lengaigne, M. Hehn, D. Lacour, S. Andrieu, M. Chshiev, T. Hauet, F. Montaigne, S. Mangin, **X. F. Han***, Y. Lu*.
Phys. Rev. Lett. **115** (2015) 157204.

[7] *Observation of magnon-mediated electric current drag at room temperature*.
H. Wu, C. H. Wan, X. Zhang, Z. H. Yuan, Q. T. Zhang, J. Y. Qin, H. X. Wei, **X. F. Han***, S. Zhang.
Phys. Rev. B **93** (2016) 060403(R).

[8] *Experimental demonstration of programmable multi-functional spin logic cell based on spin Hall effect.*
X. Zhang, C. H. Wan, Z. H. Yuan, C. Fang, W. J. Kong, H. Wu, Q. T. Zhang, B. S. Tao, **X. F. Han***.
J. Magn. Magn. Mater. **428** (2017) 401–405 (**Letter to Editor**).

[9] *Magnon valve effect between two magnetic insulators.*
H. Wu, L. Huang, C. Fang, B. S. Yang, C. H. Wan, G. Q. Yu, J. F. Feng, H. X. Wei, and **X. F. Han***.
Phys. Rev. Lett. **120** (2018) 097205, (**Editors' Suggestion** & **Featured in Physics**).

[10] *Magnon Valves Based on YIG/NiO/YIG All-Insulating Magnon Junctions*
C. Y. Guo, C. H. Wan, X. Wang, C. Fang, P. Tang, W. J. Kong, M. K. Zhao, L. N. Jiang, B. S. Tao, G. Q. Yu, and **X. F. Han***.
Phys. Rev. B **---** (2018) ----, (LU16420, accepted and at print).

Magnon Valve and Magnon Junction

X. F. Han
Institute of Physics, Chinese Academy of Sciences, Beijing 100190
Email: xfhan@iphy.ac.cn

Abstract. Compared with the electron based spintronic devices, the magnon based spintronic devices have many attractive features, including minimization of Joule heating, much longer magnon coherence length and additional phase degree of freedom. It has been expected that a device, used a core structure of Magnetic insulator [MI_1]/Space [S]/Magnetic insulator [MI_2], can also operate by method of magnon current similar to a classical spin valve (SV) and a magnetic tunnel junction (MTJ). Here, we first demonstrated a magnon valve (MI_1/S/MI_2, YIG/Au/YIG) which consists of two magnetic insulators (MI=YIG) and a nonmagnetic spacer (S=Au). Instead of regulating transport of spin- polarized electrons, the magnon valve regulates flow of magnons. We used the temperature gradient to excite the magnon current in YIG, and inverse spin Hall effect (ISHE) to detect the magnon current across the magnon valve by the electrical method. Our results show that the magnon current transmission between two magnetic insulating layers (YIG) mediated by a nonmagnetic metal (Au) has high efficiency, and the transmission of the magnon current in a magnon valve becomes high (low) as magnetizations of the two magnetic insulators are parallelly (anti-parallelly) configured. We interpret the Magnon Valve Effect (MVE) by the angular momentum conversion and propagation between magnons in two YIG layers and conduction electrons in the Au layer. The temperature dependence of Magnon Valve Ratio (MVR=11% at room temperature) shows approximately a power law, supporting the above magnon-electron spin conversion mechanism. This work conceptually proves the possibility of using magnon valve structures to manipulate the magnon current in magnetic insulators, which has potential applications in magnon based devices. [1-4]

Then, we designed and manufactured an all-insulating magnon junction with sandwich structure MI_1/S/MI_2 (S=AFI, Anti-Ferromagnetic Insulator, such as YIG/NiO/YIG), in order to achieve pure magnon transport. The devices were made on magnetron sputtering system which is a technique used for industrial large-scale production. Necessarily, the transport and manipulating properties of magnon were investigated. When the temperature gradient was applied, the magnon current would flow from one MI to the other MI through the AFI. So, the magnon current in any MI are easily influence by the other MI layer. Then setting a heavy metal Pt on the top MI layer for detecting magnon, one could find an effect that the signal of ISHE is related to the magnetization structure of both MI layers, similar to the TMR effect in an MTJ. Furthermore, the magnon valve ratio (MVR) in such magnon junctions can be increase to 100%. Hence, the electric-insulating magnon junctions can be used for developing magnon-based circuits, including non-Boolean logic, memory, diode, transistors, magnon waveguide and switches with sizable on-off ratios in near future. [5]

References:

[1] H. Wu and X. F. Han et al., Phys. Rev. Lett. 120 (2018) 097205.
[2] H. Wu and X. F. Han et al., Phys. Rev. B. 93 (2016) 060403(R).
[3] H. Wu and X. F. Han et al., Phys. Rev. B. 94 (2016) 174407.
[4] H. Wu and X. F. Han et al., Phys. Rev. B. 92 (2015) 054404.
[5] C.Y. Guo, C.H. Wan and X. F. Han et al., Phys. Rev. B. (Accepted, 2018, at print).