Division of Materials Chemistry
– Nanospintronics –

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Prof	Assoc Prof	Assist Prof	Program-Specific Assist Prof	Techn
ONO, Teruo	KOBAYASHI, Kensuke	CHIBA, Daichi	SEKIGUCHI, Koji	KUSUDA, Toshiyuki
(D Sc)	(D Sc)	(D Eng)	(D Sc)	

Students

KONDOU, Kouta (D3)
NAKAMURA, Shuji (D3)
YAMADA, Keisuke (D3)
KOYAMA, Tomohiro (D2)
NAKANO, Kunihiro (D2)
TANABE, Kenshi (D1)
CHIDA, Kensaku (D1)
SHIMAMURA, Kazutoshi (D1)
UEDA, Kohei (M2)
ARAKAWA, Tomonori (M2)
NISHIHARA, Yoshitaka (M1)
HIRAMATSU, Ryo (M1)

Visitor

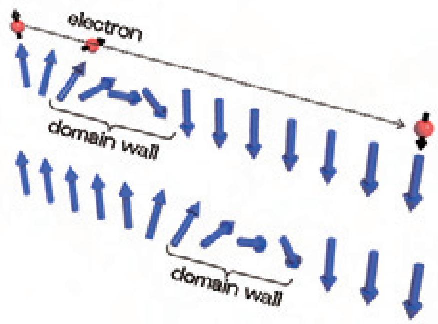
Prof WULFHEKEL, Wulf — Karlsruhe University, Germany, 25 October–4 December

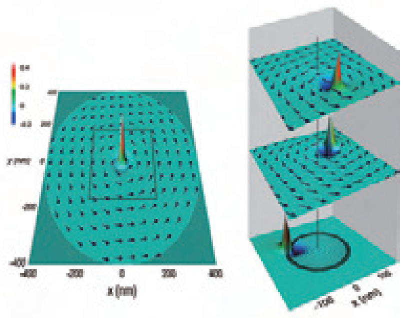
Scope of Research

The conventional electronics utilizes only the "charge" of electrons, while the traditional magnetic devices use only "spin" degree of freedom of electrons. Aiming at the complete control of both charge and spin in single solid-state devices, a new field called *spintronics* is rapidly developing and impacting on information technology. By combining the atomic-layer deposition with nano-fabrication, we focus on the development of spin properties of various materials and the control of quantum effects in mesoscopic systems for novel spintronics devices.

KEYWORDS

Spintronics
Quantum Transport
Nano-fabrication
Artificial Materials





Selected Publications

Yamaguchi A, Ono T, Nasu S, Miyake K, Mibu K, Shinjo T: Real-space Observation of Current-Driven Domain Wall Motion in Submicron Magnetic Wires, *Physical Review Letters*, **92,** [077205-1]-[077205-4] (2004).

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Yamada K, Kasai S, Nakatani Y, Kobayashi K, Kohno H, Thiaville A, Ono T: Electrical Switching of the Vortex Core in a Magnetic Disk, *Nature Materials*, **6,** 269–273 (2007).

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Delmo MP, Yamamoto S, Kasai S, Ono T, Kobayashi K: Large Positive Magnetoresistive Effect in Silicon Induced by The Space-Charge Effect, *Nature*, **457,** 1112–1115 (2009).

Nakamura S, Yamauchi Y, Hashisaka M, Chida K, Kobayashi K, Ono T, Leturcq R, Ensslin K, Saito K, Utsumi Y, Gossard AC: Nonequilibrium Fluctuation Relations in a Quantum Coherent Conductor, *Physical Review Letters*, **104,** [080602-1]-[080602-4] (2010).

Spin-wave Manipulation

Spin-wave-based devices for signal processing have been of great interest for the spintronic integrated circuits in virtue of ultrafast propagation and low power consumption. In FeNi film, the magnetostatic surface wave (MSSW) is the promising mode due to its large propagation velocity and a nonreciprocal character which was also observed a long time ago in yttrium iron garnet films. We demonstrate the nonreciprocal emission of spin-wave packet in FeNi thin film in time domain. We show that the amplitude of spin wave depends on the direction of magnetization and that the phase of spin wave can be controlled by the polarity of pulsed magnetic field for the excitation. Our findings lead to the simple method of logical inputs of "1"/"0" into the spin-wave logic circuit.

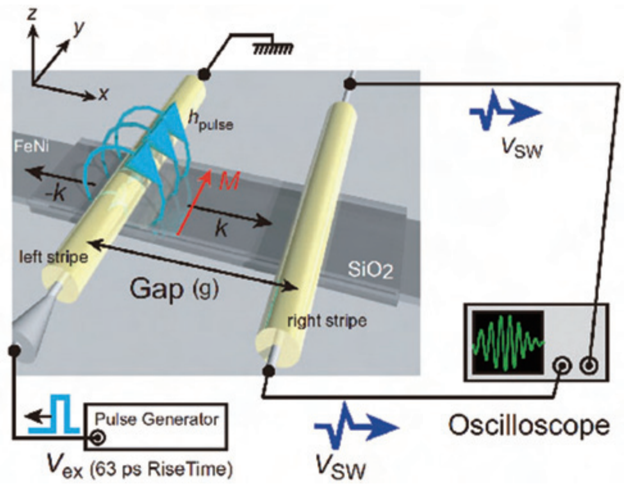

Figure 1. Schematic of time-resolved measurements of spin wave packet. A spin wave packet is generated and detected with a pair of asymmetric coplanar stripe with a gap.

Fluctuation Theorem in Quantum Regime

The linear-response theory, which is one of the triumphs in physics, was proposed in 1950's. Triggered by Einstein's work on the Brownian motion followed by the Johnson-Nyquist relation in an electrical circuit, the fluctuation-dissipation relation has been developed into the linear-response theory, which successfully relates a macroscopic irreversible process with underlying microscopic reversible equation of motion. The theory is now well-established as a standard tool to quantitatively predict the response of a variety of physical systems, and constitutes a reliable foundation in a wide range of physics, especially in statistical physics and condensed-matter physics. However, it is only justified very close to the equilibrium, and therefore an intensive attempt to expand the theory to non-equilibrium regime has been conducted for about half a century. In 1990's, the fluctuation theorem (FT), which is validated even far from equilibrium, was discovered. While there is an experimental demonstration of its validity in a classical regime, the validity of FT in the quantum regime was left to be addressed. We experimentally demonstrate the presence of higher-order correlations between the current and the current noise in a mesoscopic electron interferometer, which corresponds to the next order correlation following to the Johnson-Nyqusit relation. Our results qualitatively validate the predictions based on FT, being the first experimental evidence of FT in the non-equilibrium quantum regime.

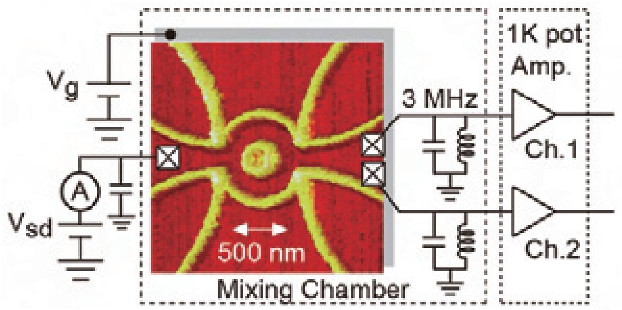

Figure 2. The atomic force microscope image of the mesoscopic electron interferometer, where our experimental test of FT was performed. The measurement setup is schematically shown.