Single Quantum Dynamics Research Group

Group Director
Akira Tonomura (D.Eng., Ph.D.)

This project aims at a deeper understanding of quantum phenomena through precise observations and further development of modern technologies by studying new phenomena and next-generation devices. The world-leading development of a high-brightness electron beam put Japan to the forefront of a new field of research, quantum wave science. There is great potential in this field for innovative applications in quantum mechanics. With our intensive activities in frontier scientific fields, such as superconductivity, magnetism, quantum computing, complex spatio-temporal dynamics in materials, and high-performance computer modeling of novel physical phenomena in solids, we hope to initiate a new trend in scientific and industrial prosperity in Japan, that will lead the world into a more prosperous 21st century.

Digital Materials Lab.

Laboratory Head
Franco Nori (Ph.D.)

We perform theoretical studies of complex dynamics in materials. We use physically-motivated models to make predictions which can be tested experimentally and are useful to better understand the observed phenomena. We are currently working on several projects, including: quantum computing (superconducting Josephson-junction qubits, scalable quantum circuitry, improved designs for its control, coherent oscillations, and readout), vortex dynamics in superconductors, new fluxtronics devices, complex collective phenomena, nano-magnetism and spintronics. We are also working on biologically-inspired solid-state devices that can control the motion of quanta.

Macroscopic Quantum Coherence Lab.

Laboratory Head
Jaw-Shen Tsai (Ph.D.)

We study macroscopic quantum coherence in small Josephson junction circuits. We have shown that in these circuits it is possible to control the coherent quantum state by gate voltage, magnetic field, and microwave irradiation. The macroscopic quantum coherent oscillations was observed in this system at our lab, and it was the realization of the first solid-state quantum bit (qubit). For this system, we are studying the decoherence mechanism, quantum entanglement, scalable quantum circuits, and other related subjects. These studies are relevant for the realization of future quantum computers.

Quantum Nano-Scale Magnetics Lab.

Laboratory Head
Yoshichika Otani (D.Sc.)

Nano-scale magnets can have, according to their shape and size, ordered domain structures such as magnetic vortices and single-domains. Using experimental and theoretical approaches, we study static and dynamical magnetic properties of nano-scale magnets, to obtain a better understanding of the quantum behavior associated with domain wall displacement and magnetization reversal. Moreover, we employ spin injection techniques using nano-scale magnets as electrodes which provide spin-polarized current. This spin-injection induced magnetism will be applied to the development of novel spintronic devices.

Quantum Phenomena Observation Technology Lab.

Laboratory Head
Akira Tonomura (D.Eng., Ph.D.)

For better understanding quantum phenomena, advanced technologies for directly observing electric and magnetic fields in a nanoscopic region under specific conditions are required. In order to reach this goal, we are developing visualization techniques for phenomena appearing in various scientific fields by making full use of the wave nature of an electron beam. Our team inherited the advanced technologies which have succeeded in the confirmation of the Aharonov-Bohm effect by electron holography and the first direct observation of vortices inside superconductors by Lorentz microscopy. New applied research is also expected to contribute to nano-technologies by using the specialized field-emission electron microscope in which the electron beam behaves as a wave.