【Grant-in-Aid for Scientific Research (S)】

Broad Section B

Title of Project： Investigation of nuclear spin-current science and nuclear thermoelectric conversion

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Research Project Number：19H05600　Researcher Number：80338251
Keyword：Spintronics, Spin current, Nuclear spintronics, Nuclear spin current

【Purpose and Background of the Research】

In this project, we will explore a new research field "Nuclear spin-current science" connecting nuclear spins and spin-current science. Over the past decade, the spin-current science has produced various functions for electronic devices by utilizing spin angular momentum of electrons. On the other hand, spin angular momentum of nuclei has not been used in terms of spin currents. Therefore, in this project, we will investigate spin current phenomena caused by nuclear spins and expand the spin current science into a larger framework including nuclear spin currents.

Spintronics aims to produce new physical properties and electronic functions by utilizing electron spins. Spintronic devices have been developed as basic technologies essential to information society, such as the realization of magnetic random access memories (MRAMs). Spin current, the spin counterpart of the electronic charge current, is one of the most important concepts in spintronics, with most of the spintronic functions related to the angular momentum carried by the spin currents. Various other concepts related to angular momentum in solids, such as magnetizations and phonons, have already been united to the spin current framework. In contrast, despite the potential of nuclear spins to be utilized in quantum sensing and information transport technologies, they have remained unconnected to the spin-current science.

Under such backgrounds, we recently discovered "nuclear spin pumping" which generates spin currents from nuclear spins. The discovery established a detection method for nuclear spin currents, enabling investigations of nuclear spin-current physics. In this project, we will investigate nuclear spin-current phenomena and explore a new research field "Nuclear spin-current science".

【Research Methods】

The discovery of the nuclear spin pumping realizes spin current generation from nuclear spins and opens the way for connecting nuclear spins and spin current science.

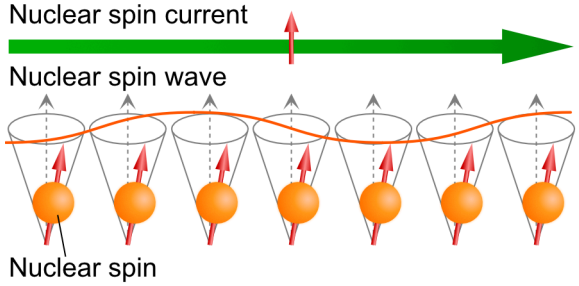

Figure 1 Nuclear spin current

Thanks to this discovery, the detection and quantitative evaluation methods for the nuclear spin currents are established for the first time. By combining the detection method and conventional wisdom of the electron spin-current science, it is now possible to discover and develop further nuclear spin-current phenomena and explore the nuclear spin-current science.

【Expected Research Achievements and Scientific Significance】

In this project, we will explore a new research field "Nuclear spin-current science". By combining nuclear spins and spin current science, we will realize intrinsically new and valuable phenomena, and construct an extended framework of spin current science. The nuclear spin-current science paves the way to utilize the spintronics technologies in various research fields such as solid state chemistry, materials chemistry, and biology, where nuclear spins are used as a probe for physical properties. We aim to contribute not only to the nuclear spin-current physics but also to a wide range of sciences.

【Publications Relevant to the Project】

・E. Saitoh, M. Ueda, H. Miyajima, and G. Tatara, "Conversion of spin current into charge current at room temperature: Inverse spin-Hall effect" Applied Physics Letters **88**, 182509 (2006).
・Y. Shiomi, J. Lustikova, S. Watanabe, D. Hirobe, S. Takahashi, and E. Saitoh, "Spin pumping from nuclear spin waves" Nature Physics **15**, 22-26 (2019).
・K. Harii, Y.-J. Seo, Y. Tsutsumi, H. Chudo, K. Oyanagi, M. Matsuo, Y. Shiomi, T. Ono, S. Maekawa, and E. Saitoh, "Spin Seebeck mechanical force" Nature Communications **10**, 2616 (2019).

【Term of Project】 FY2019-2023

【Budget Allocation】 158,700 Thousand Yen

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