World's first direct observation of the magneto-Thomson effect

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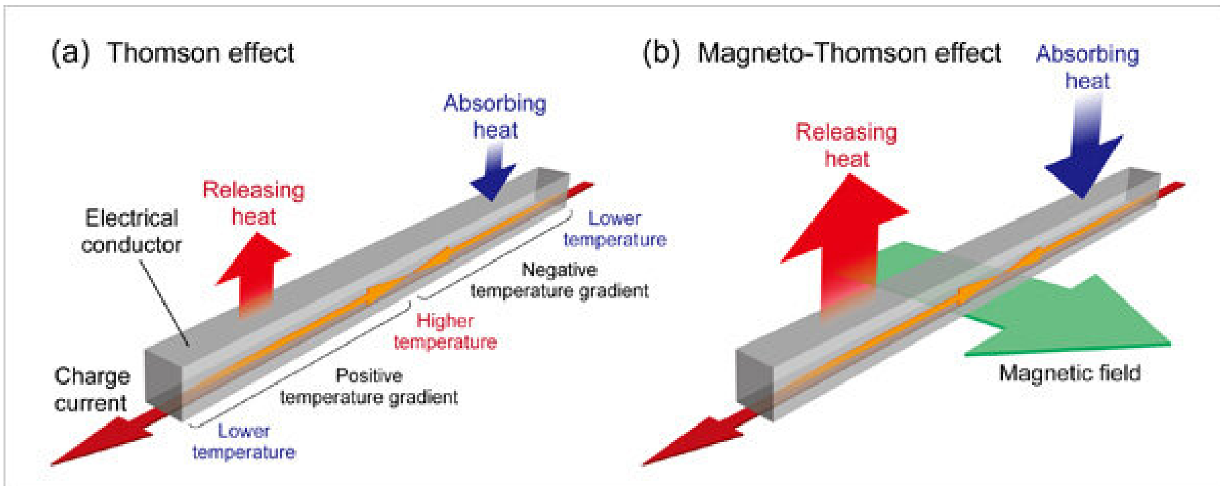

Figure 1. Schematic illustration of the Thomson effect and the magneto-Thomson effect. Credit: National Institute for Materials Science

Applying a temperature gradient and a charge current to an electrical conductor leads to the release and absorbtion of heat. This is called the Thomson effect. In a first, NIMS and AIST have directly observing the magneto-Thomson effect, which is the magnetic-field-induced modulation of the Thomson effect. This success may contribute to the development of new functions and technologies for thermal energy management and to advances in fundamental physics and materials science on magneto-thermoelectric conversion.

The Seebeck effect and the Peltier effect have been extensively investigated for their application to thermoelectric conversion technologies. Along with these effects, the Thomson effect has long been known as a fundamental thermoelectric effect in metals and semiconductors. Although the influence of magnetic fields and magnetism on the Seebeck and Peltier effects has been well understood as a result of many years of research, the influence on the Thomson effect has not been clarified because it is difficult to measure and evaluate.

This NIMS-led research team observed heat release and absorption induced in an electrical conductor by simultaneously creating a temperature gradient across it, passing a charge current through the gradient, and applying a magnetic field. The team precisely measured temperature changes in the conductor associated with the heat release and absorption using a heat detection technique called lock-in thermography. As a result, the amount of heat released and absorbed was found to be proportional to both the magnitude of the temperature gradient and charge current. In addition, the team observed strong enhancement of the resultant temperature change when a magnetic field was applied to the conductor. The systematic measurements performed in this study demonstrated that the heat release and absorption signals detected under a magnetic field were indeed generated by the magneto-Thomson effect. This effect observed in the bismuth-antimony alloy used in this experiment exhibited very high thermoelectric conversion performance, which can reach the level of thermoelectric conversion performance of the Seebeck and Peltier effects.

This research revealed the fundamental nature of the magneto-Thomson effect and established techniques to measure and evaluate the effect. We will continue the physics and materials science studies on the magneto-Thomson effect and create new thermoelectric conversion functions based on this effect. Specifically, we plan to apply it to the development of thermal management technologies that can be used to increase the efficiency of electronic devices. We also hope to observe new physical phenomena involving interacting heat, electricity, and magnetism.

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More information: Kelly Morrison et al. Thermal Imaging of the Thomson Effect, *Physics* (2020). DOI: 10.1103/Physics.13.137

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