Development of a Cryogenic Adiabatic Calorimeter Using a Pulse-Tube Cryocooler

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The specific heat capacity of solids at low temperatures is an important thermodynamic property useful for engineering and materials science. Adiabatic calorimetry is one of the most reliable techniques to measure heat capacities of solid materials at cryogenic temperatures. This method, however, usually takes much time and effort. We have tried to improve the handling of this traditional calorimeter by applying a pulse-tube cryocooler to the apparatus. Because of the recent progress in cryogenics, this type of cryocooler can easily make a low temperature environment down to liquid helium temperatures without any cryogen or special skilful operations. It is expected that this improvement can bring us the several advantages of easy operation, easy automation, long-term stable measurements, inexpensive maintenance, and so on. On the other hand, the cryocooler has a big shortcoming: it generates mechanical vibrations unfavorable for measurements in the sub-Hz range. This problem was well settled by using rigid stands that were independent for the cryocooler head, the rotary valve, and the calorimeter cryostat. Adiabatic controls have been improved by introducing a software PID process for the isothermal control of a cell, an inner-shield, and an outer-shield. We have also developed user-friendly operating software for the hardware, and have a final goal of providing a reliable and convenient adiabatic calorimeter to the market. This research was operated under a technology transfer program supported by the JST (Japan Science and Technology Agency).