The CMP Specific-Heat Experiment

An early success of quantum mechanics was to explain the temperature variation of the specific heat of bulk macroscopic material. While the molar specific heat (at constant volume) c_p of any material is predicted to be $3R$ on the basis of classical thermodynamics, many materials exhibit deviations from this value, deviations the more marked the lower the temperature. The initial Einstein model, and the later Debye model, of quantized oscillators provided early experimental support for the applicability of quantum mechanics to the macroscopic behavior of bulk matter.

TeachSpin has chosen the measurement of specific heat as a worthy goal in fundamental condensed-matter experiments, in part to test Einstein/Debye models, in part to introduce phase transitions, and in part to provide the raw data for the entropy content of materials. We have elected to measure specific heat via the measurement of heat capacity, in a form of vacuum **heat-pulse calorimetry**.

Our Dewar system includes all the environment required, in that we provide an inner chamber which can be temperature-controlled and evacuated. Inside this chamber we mount an '**addendum**', a thermally-isolated sample-holder equipped with a built-in heater and transdiode temperature transducer. The heat increment ΔQ is electrically-generated and accurately quantified, and the temperature rise ΔT is related to the heat capacity C of the sample via

$$\Delta Q = C\,\Delta T \quad .$$

Temperature increments of $\Delta T < 1$ K are easily resolved with adequate precision. With a 'bare addendum' characterized as a function of temperature T in the range 80 – 400 K, the experiment can be repeated with a solid, or epoxy-bonded powder, attached to the addendum. Now the heat capacity C is made up of contributions

$$C = C_{addendum} + C_{sample} = C_{addendum} + m_{sample}\,c \quad ,$$

and this provides the **specific heat** c of the sample alone.

With our specific-heat experiment we provide a dozen **prepared samples**, some solid, others epoxy-bonded powders, and we also provide all that's needed for users to create their own samples as well. Our prepared samples include some materials of rather lower, and rather higher, Debye temperatures, and other materials exhibiting **phase transitions** detectable through specific-heat measurements.