Experiment H-4

Specific Heat Discontinuity due to a Order-Disorder Transition and a Ferromagnetic Phase Transition

Measure the specific heat of beta brass and of nickel as a function of temperature up to 500 celsius. Compare the shapes of the curves with each other and with theory and investigate the mathematical form of the curves near the singularity both above it and below it.

References:

*Special Notes
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PROCEDURE

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Place the sample in the container making sure that the thermocouple in the center of the container is in firm contact with the sample. Place the container in the oven, and turn on the forming gas, a mixture of 94% nitrogen and 6% hydrogen, used to help slow down sample oxidation. Set the pressure valve on the gas cylinder to about 10 p.s.i. and let the gas flow into the oven at about 4 cubic feet/hour (cfh) to flush the system. Reduce the flow to about 2cfh after 5 to 10 minutes.

Next turn on the oven to a power level of about 450 Watts. You may also wish to try settings of around 300 watts to get heating rates of roughly the same magnitude as cooling rates. Be consistent whichever you decide.

When the temperature reaches approximately 500 Celsius, turn off the oven. Once the temperature readout has fallen below 200 degrees Celsius one may stop taking data. Note that it is not necessary for the oven to be at room temperature before beginning the next run. However, care must be taken not to burn oneself on the hot surfaces of the container during a high temperature sample change.

H-4 Thermocouple Readout

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The experiment uses two temperature measurements, both of which are read into an IBM PC computer. The temperature of the sample is determined using a Chromel-Alumel thermocouple referred to an ice-water bath. Make sure that the thermocouple is in good contact with your sample – this is important to getting good data. The readout for this thermocouple is through a Hewlett-Packard 3478A digital voltmeter (DVM). Communication between the IBM PC and the DVM is via GPIB interface.

The gradient reading comes from 6 Chromel-Alumel thermocouples connected in series across the sample holder as shown in Figure 1. The readout for the gradient is through a home-built box described in the Technical Notes below.

To collect data, you will run a program called H4V4C, which records the time and the two temperature readings every few seconds. When you start the program it will ask you to calibrate the gradient thermocouple, first by shorting together the inputs to the box, and then by delivering a known voltage. A jumper is provided to do the job of shorting together the inputs of the box. To deliver the known voltage, there is a small supply with a 1000:1 attenuator on the output. A suitable choice is 4V from the supply, which then delivers a voltage of 4mV into the box. The exact voltage used can be read with the second Hewlett-Packard 3478 multimeter.

A word of caution: the computer that is currently used for data acquisition runs into trouble for file sizes greater than about 100,000 bytes. Consequently, if you intend to run for a long time, break the data into several shorter files.

Technical Notes

Sample Temperature Read-out

The HP 3478A DVM that reads out the sample temperature uses a GPIB interface. The most common cause of a GPIB error is that the address is wrong, either on the DVM or in the computer. Run CONFIG on the IBM PC if address errors are suspected, and check that DVM has primary address OlH (address 'one'). The address of the DVM should be set to 00000001 = 'one' on the DIP switches at the back of the DVM. Caution: One must cycle the power or do an address check on the front panel of the DVM before a new address is accepted.

Gradient Read-out

The box used to measure the gradient uses an Analog Devices 2B54A thermocouple/mV conditioner as the input element. This conditioner does the important jobs of providing common mode rejection, filtering and amplifying the thermocouple signal. Its gain is set by a 10 ohm resistor and is $G = 1 + 10^4/10 = 1001$ (The gain can be adjusted with the “gain" potentiometer, but this is not normally necessary). With this gain, the output range of +- 5V corresponds to an input range of +-5mV. The output of the 2B54A is measured with a Datel ADC-EKI2B integrating ADC. This 12-bit ADC is connected for bipolar operation of +-5V. The "offset" potentiometer controls the ADC reading with zero input. The ADC reference voltage is provided by a National LM313 reference diode. A circuit diagram of the box is included in this write-up along with data sheets for the 2B54A, ADC-EK12B and LM313. Communication between the IBM PC and the homemade amplifier is via an IBM Data Acquisition and Control Adapter (a fancy ADC). Manuals for this and the GPIB adapter are in the lab.

DOCUMENTATION FOR FORTRAN PROGRAM H4.FOR

Albert Putnam -January 1989

USE: **Physics 510 Experiment H4, Specific Heat Discontinuity due to an Order- Disorder Transition and** a **Ferromagnetic Phase Transition.**

PROGRAMMERS:

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H4.FOR is designed to take temperature and gradient data passively from a free running oven. No temperature or heating control is involved.

An HP3478 Digital Voltmeter (DVM) is used in the experiment to read the sample thermocouple voltage. A homemade amplifier, described elsewhere in the H4 notes, is used to read the gradient voltage from a six-thermocouple thermopile, which monitors gradient across the sample container. The homemade amplifier was found, in the fall of 1988, to have noise problems, and half of its function (monitoring sample thermocouple voltage) was superseded by the digital voltmeter (DVM). In the future its function may be completely superseded by the use of two DVM's, and the modification of H4.FOR.

It should be noted that the real meat of this lab is in the data analysis. The data taking program should run smoothly and faithfully with minimal programming knowledge required from the user. Prospective modifications should be considered with this in mind.

H4.FOR is commented, but a quick outline is in order.

1 -variable declarations

2 -initialize DVM GPIB adapter

3 -initialize ADC

4 -calibrate the ADC conversion

5 -open the data file

6 -user instructions

7 -data taking loop

A -read DVM

B -read Time

C -read ADC

D -convert voltages to temperatures using TCONV (See below)

E -delay to allow DVM to settle

F -check data and log if change in temperature greater than 1 K.

G -go back to A or break out

8 -close up the data fIle

TCONV .FOR is a subroutine that converts chromel-alumel thermocouple voltages to temperature using a fourth order polynomial fit to the thermocouple table found in TABLE.DAT. It must be compiled and available as TCONV .OBJ when linking H4. Interpolation was once used to calculate temperature, but finite table precision and the fact that data is taken at the same interval that the table values are given at, caused a shocking interference noise effect.

The following files are associated with H4:

H4.FOR -described above, listing follows
TCONV .FOR -described above, listing follows

H4.LNK -used to link H4 (LINK @H4.FOR), list follows

TABLE.DAT -thermocouple table

TCONV.OBJ -TCONV link module

DACF.OBJ -ADC link module

FIB.OBJ -GPIB link module (must be linked last)