Specific heat, magnetic susceptibility, and the spin-glass transition in $Hg_{1-x}Mn_xSe$

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The specific heat of the two mercury compounds $Hg_{1-x}Mn_xTe$ and $Hg_{1-x}Mn_xSe$ is almost identical. The phase diagram for $Hg_{1-x}Mn_xSe$ is more complete and is different from that of $Hg_{1-x}Mn_xTe$. The specific-heat data for low Mn concentration are still not understood.

Recently we communicated the results of a systematic study of the low-temperature specific heat and the low-field magnetic susceptibility on the mixed crystals $Hg_{1-x}Mn_xTe$,[1] and $Cd_{1-x}Mn_xTe$.[2] In a continuation of these works similar investigations were carried out on $Hg_{1-x}Mn_xSe$ crystals, in the composition range $0 < x \leq 0.32$. The two mercury compounds have the same crystal and band structures, and the only difference is the substitution of selenium for tellurium. This substitution changes the lattice contribution slightly; this has been reported elsewhere.[3] The magnetic contribution by the Mn ions to the specific heat appears to be independent of this change. Therefore we give the results in graphical form and refer back to Ref. 1 for a full discussion of the method of preparation of these crystals, experimental method and the results.

An overview of the experimental results of the specific heat at $H = 0$ for all measured samples is presented in Fig. 1 as plots of $\log C$ versus $\log T$. The results for the low-field magnetic susceptibility are shown in Fig. 2 as plots of χ vs T. From the

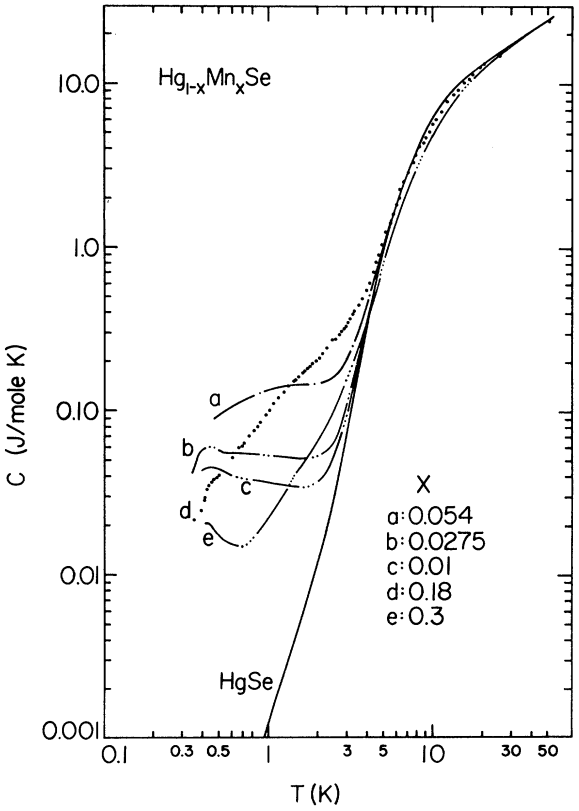

FIG. 1. Specific heat of $Hg_{1-x}Mn_xSe$ in zero magnetic field is shown as plots of log C vs log T.

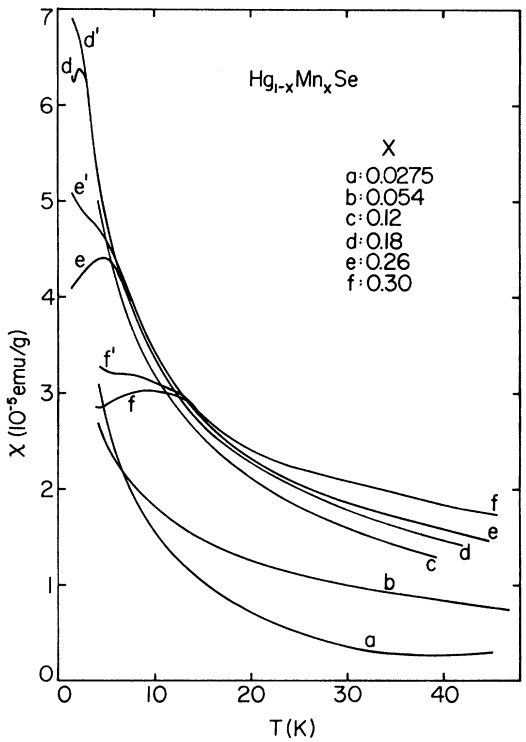

FIG. 2. Magnetic susceptibility of $Hg_{1-x}Mn_xSe$ as a function of temperature. The labels with superscript prime (such as: d', e', f') and those without any superscript indicate field-cooled and zero-field-cooled susceptibilities, respectively.

specific-heat and magnetic-susceptibility measurements we distinguish paramagnetic and spin-glass regions and a schematic phase diagram is shown in Fig. 3. The low-temperature extension of the boundary between paramagnetic and spin-glass phases gives $x_c \gtrsim 0.16$ which is in excellent agreement with the simplest estimate of the percolation threshold value for an fcc lattice: $x_c = 0.17$. Surprisingly the phase diagram for $Hg_{1-x}Mn_xTe$ appears to be different. For $Hg_{1-x}Mn_xTe$,[1] only the sample with $x = 0.35$ showed spin-glass behavior out of the three samples with concentration above the percolation limit. The temperature of the cusp in the susceptibility of this sample fits quite well on the phase diagram for the selenium compound. At the time we were investigating the tellurium compounds we were already worried about the absence of spin-glass behavior for $x = 0.22$ and 0.25 and therefore extended the temperature range for $x = 0.25$ down to 1.2 K.

The specific heat of two samples of $Hg_{1-x}Mn_xSe$ in the spin-glass regime show a linear term, γT, at low temperature. This has also been observed for the canonical spin-glasses AuFe,[4] and CuMn, [5] as well as for the spin-glass system $(Ti_{1-x}V_x)_2O_3$,[6] for $0.2 > x > 0.01$, and also for $Cd_{1-x}Mn_xTe$.[2] Except for the canonical spin-glasses, the other systems show that the coefficient, γ, decreases with increasing value of the concentration, x.

As has been reported earlier,[1,2] for small concentration of Mn ions ($x < 0.05$) the specific-heat data

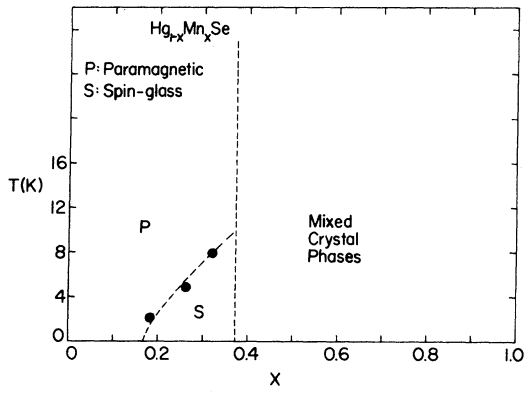

FIG. 3. Schematic phase diagram of $Hg_{1-x}Mn_xSe$ for temperature vs Mn concentration x. Regions P and S indicate paramagnetic and spin-glass phases, respectively.

cannot be explained both by statistical as well as modified distribution models[1] and is still a puzzle.

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