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COMMENT ON "SURFACE MAGNETIZATION OF Gd AT THE BULK CURIE TEMPERATURE"

by

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ABSTRACT

We comment on the discontinuity of the first temperature derivative, at the bulk critical temperature, of the surface magnetization of ferromagnets with a free surface, question which has recently been focused by Rau and Robert.

Key-words: Phase transitions; Surface magnetism; Ising ferromagnet; Renormalization group.

In a recent paper[1], Rau and Robert address a controversial point, namely, of what type is the singularity which is expected to appear in the surface magnetization m_s of a magnetically ordered bulk at the bulk critical temperature T_c^{bulk}. In other words, in the vicinity of T_c^{bulk} it is expected

$$m_s(T) - m_s(T_c^{bulk}) \sim \begin{cases} A_-(1 - T/T_c^{bulk})^{\chi_-} & , \quad \text{for } T < T_c^{bulk} \\ -A_+(T/T_c^{bulk} - 1)^{\chi_+} & , \quad \text{for } T > T_c^{bulk} \end{cases} .$$

The central questions therefore are what the values of A_+/A_-, χ_+ and χ_- are. The experimental data of Rau and Robert in Gd give support to the possible continuity, at T_c^{bulk}, of both $m_s(T)$ *and* its first derivative. On the other hand, accurate experiments[2] on liquid ^{4}He (whose criticality is expected to be the same as that of some surface magnetic systems) indicate a *discontinuity* in the first derivative. Mean-field-like theories yield continuity in the first derivative, whereas a RPA treatment for a quantal anisotropic Heisenberg model has suggested a discontinuity[3]. On the whole, the point remains unsolved. In particular, Rau and Robert state that no successful renormalization-group calculation is available to clarify this particular question. We are presently performing a real-space renormalization group calculation which precisely addresses this problem for the spin 1/2 Ising ferromagnet in

semi-infinite simple cubic lattice with a (001) free surface. In this model, the coupling constant between two sites equals J_S if both sites belong to the surface and equals J_B otherwise. We present in the figure a typical result provided by our method (based on the procedure described in Ref. 4). We will publish elsewhere full details on the method and the rest of the results. We clearly see that the first derivative of $m_S(T)$ is *discontinuous* at T_c^{bulk}. Furthermore, we verify that $\chi_+ \cong \chi_- \cong 1$ and A_-/A_+ is roughly equal to 4, for a large variety of typical ratios J_S/J_B. We believe that $\chi_+ = \chi_- = 1$ and $A_-/A_+ \neq 1$ is a quite generic situation. This should be a consequence of the influence on $m_S(T)$ of the bulk. Indeed the bulk acts through two different physical channels. The first one is the obvious fact that the bulk magnetization, as long as non-vanishing, acts as an effective field on the surface. The second channel, more subtle, refers to bulk susceptibility effects, in which it is to be taken into account that in the neighbourhood of T_c^{bulk}, the paramagnetic-side amplitude of the susceptibility is higher (2 times higher in standard mean field calculations) than that of the ferromagnetic-side amplitude. The effect of the paramagnetic-side bulk susceptibility overcomes both the effects of the vanishing bulk field and of the bulk susceptibility just below T_c^{bulk}, thus explaining the decrease in the tendency of the surface to disorder in the region just above T_c^{bulk}. Within this approach the fact that mean-field calculations yield $A_+ = A_-$ would be fortuitous and possibly related to the factor 2 mentioned above. Summarizing, at the light of the renormalization-group

results herein illustrated (on the figure), we see that the result $A_+/A_- = 1$ experimentally obtained by Rau and Robert should not be considered the generic situation, and its comprehension should be searched elsewhere.

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CAPTION FOR FIGURES

Fig. 1 - Surface magnetization m_S as a function of the ratio T/T_c, for $J_S/J_B = 2.5$. The bulk magnetization m_B is also shown as a reference.

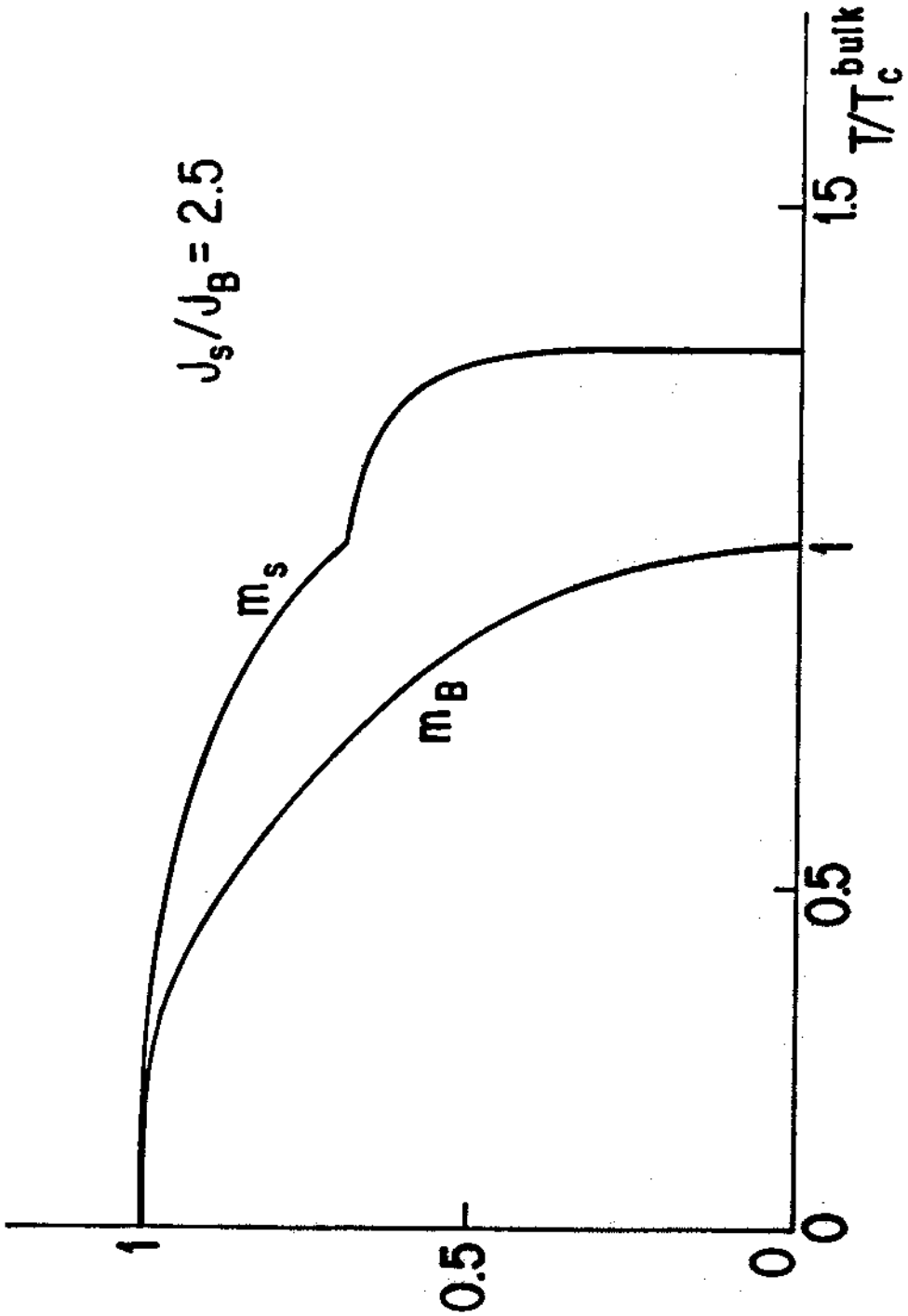

Fig. 1

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