DYNAMICS OF THE CLASSICAL PLANAR SPIN CHAIN

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Résulté.- La technique Monte Carlo a été utilisée pour calculer les moments de la fonction de relaxation pour la chaîne de spins classiques avec anisotropie dans le plan x-y. Ainsi on obtient des résultats détaillés pour les propriétés dynamiques. Comparaison est faite avec l'expérience et autres théories.

Abstract.- The Monte Carlo method has been used to calculate the moments of the relaxation function for the classical planar spin chain. In this way extended results for the dynamic properties of this system are obtained. Comparison is made with experiment and other theories.

In a previous paper the authors presented a method, based on the projection operator formalism, to obtain expressions for the relaxation function in a systematic way /1/. It was shown, that taking a spin component and its first two time derivatives as relevant variables, the normalized relaxation function can be written as

\[ \psi_k(z) = \frac{z^2 + \sum_k(z)(<\omega_0^2>_k - <\omega_0^2>_k)}{z(z^2 - <\omega_0^2>_k + \sum_k(z)(<\omega_0^2>_k)} \] (1)

In the simplest approximation the transport coefficient \( \Sigma_k(z) \) was found to be given by /1/

\[ \Sigma_k(z) = -\frac{<\omega_0^2>_k - <\omega_0^2>_k}{z + i\left[<\omega_0^2>_k - 2<\omega_0^2>_k + <\omega_0^2>_k + <\omega_0^2>_k^{2/3}\right]} \] (2)

The relaxation function is now completely determined by its moments \( <\omega_0^2>_k, <\omega_0^2>_k, \) and \( <\omega_0^2>_k, \) and it satisfies the sum rules

\[ <\omega_0^2>_k = -\frac{1}{\pi} \int_0^\infty dw \omega^{2n} \text{Im} \psi_k(\omega) \quad n = 1, 2, 3, \] (3)

identically.

The classical planar spin chain is described by the hamiltonian /2,3/.

\[ H = -\sum_i (S_i^x S_{i+1}^x + A) \sum_i (S_i^z)^2, \] (4)

where the spins are classical unit vectors, and we will take \( A = 0.21 \), corresponding to the anisotropy in \( \text{CdNiF}_3 \), for which measurements were made by Steiner and al. /4/. Loveluck and al. calculated some moments using the transfer operator method /5/. But because the higher moments are very complicated expressions, that give not much physical insight, we have used a Monte Carlo simulation to calculate these quantities numerically. A more complete description of the method, and extended results will be presented in a forthcoming paper /6/. Some results will now be summarized.

In figure 1 bare results for the moments are shown for the temperature \( T = 0.5 \). The moments of the x-component do not disappear at zero wave vector, because the total spin in the x-direction is not a conserved quantity, in contrast with the total spin in the z-direction. In figure 2 we give some results for the imaginary part of the relaxation function for the wave vector \( k = 0.25 \pi \). At lower temperatures the width of the spin wave peak of the z-component is extremely small, which means that the excitations are almost undamped. At higher...
temperatures the peak of the $z$-component seems to disappear more rapidly than that of the $x$-component. The difference between the $x$- and $z$-components at low-temperatures can be understood in terms of the correlation lengths. At zero temperature the correlation length $\xi_x$ diverges, because the spins order ferromagnetically in the $x$-$y$ plane, while $\xi_z$ remains finite /6/.

Our results agree with the experimental observations on CsNiF$_3$ /4/, and with the theoretical results for the $z$-component obtained by Loveluck et al. /3/, /5/.

References

/6/ De Raedt, B. and De Raedt, H., to be published in Phys. Rev. B.