Magneto-Elastic Effect in the Mean Field Approximation

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Abstract

We deduce magneto-elastic constants in the ordered state by means of the mean field approximation, arising from exchange interactions dependent on distances between spins. The constant constitutes two parts, in which one includes the square of sublattice magnetization and other does the product of the square of the magnetization and the staggered susceptibility. It is denoted that the contribution of both parts to the constants varies according to the magnetic system.

1. Introduction

We derived the exchange striction in previous paper[1] denoted by Ref. 1. Similar method can lead magneto-elastic constants.

Elastic constants of magnetic substances have been measured by many authors[2~8]. There are many reports[9,10] related them with the critical phenomena. However, it seems that the variation for all temperatures is not explained theoretically enough.

We use the mean field approximation, so say, the molecular field one. The theory can explain magneto-elastic behaviors for temperatures below the transition point qualitatively. In next section we give the theory. In section 3 we discuss the result and compare it with experimental results.

2. Theory

We here repeat a little part in Ref. 1 to clear the idea. We use the same Heisenberg Hamiltonian for localized magnetic ions to Ref. 1,

$$H=\sum_{l}\sum_{m}{}' J_{lm}\boldsymbol{S}_l \cdot \boldsymbol{S}_m. \tag{1}$$

It is supposed that the magnetic system has a spin only in the unit cell, that is, one kind of spin. In Eq. (1), the summation with the prim is to include all spin sites except $m=l$ in the unit volume and one without it is carryed out over all sites in the same space. The exchange interaction between the l'th spin and the m'th spin is $-2J_{lm}\boldsymbol{S}_l \cdot \boldsymbol{S}_m$. It is important in our consideration that the exchange constant J_{lm} depends on the inter-atomic distance for any spin pair. We investigate magneto-elastic effects due to the exchange interactions dependent on the distance in the mean field approximation.

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