Study of Synthetic Antiferromanet Based on a Geometrical Approach

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I. Introduction

The synthetic antiferromagnet (SAF) structures are intensely studied due to their potential applications in magnetic random access memory, perpendicular magnetic recording and magnetic sensors. The recent theoretical studies of SAF structures have used a critical curve approach [1, 2]. Unfortunately it is rather difficult to understand the response of the system using this method. It is well known that the Stoner-Wohlfarth (SW) theory provides a geometrical method based on critical curve to establish the equilibrium states of the magnetic moment for a single particle [3, 4].

II. Purpose

In this paper one presents a new critical curve approach based on the considerations provided by SW model applied for the SAF structure. We have developed a method to understand the behavior of the structure using the approach for the isolated single-particle case. This allows an intuitive way to characterize the stable and saddle points.

III. The Method

Using SW model, the total free energy density of SAF normalized by $2K_1t_1$ can be expressed as equation (2) from [2], the energy being a function of two variable: θ_1, θ_2.

The basic idea of the method is to develop a geometrical method which must be related to the minimum conditions. Considering θ_2 fixed and θ_1 variable, expressing $w_1=0$, $w_{11}>0$ and assigned the equality case to the last one, we obtain two perpendicular lines, the first one being the equilibrium line and the second one the stable line in the (h_x, h_y) plane. Solving the system, the projections of the applied field represents an astroid not centered in the origin of the coordinates system, like for a single particle case, but one situated on a circle with the radius equal to h_J, making a θ_2 angle with the easy axis (Fig.). The equilibrium line is tangent to the astroid making θ_1 angle with the abscissa. So, for an equilibrium state, the field must be applied with the initial point in the origin of the plane and the terminal point on that specific part of the equilibrium line placed on the stable region.

One may also suppose θ_1 fixed and θ_2 variable, with the associated conditions: $w_2=0$, $w_{22}>0$. Using same analysis there is obtained a similar result with the following remarks: the astroid has the characteristic length k/m, the radius of the

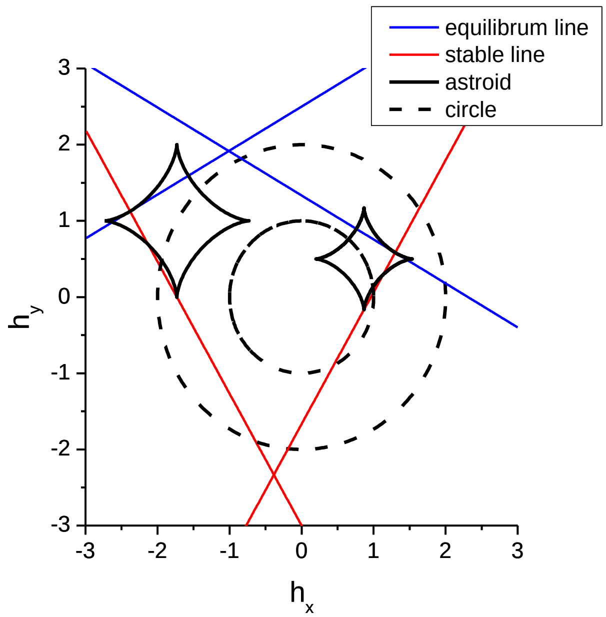

Fig. The astroids, circles equilibrium and stable lines for $h_J=2$, $k=1$, $m=1.5$ and $t=1.33$ when $\theta_2=150°$ and $\theta_1=30°$.

circle is h_J/mt and it makes θ_1 angle with the abscissa (Fig.). It is obvious that the two situations presented refer to the first and second order derivates conditions neglecting the discriminant. For a given equilibrium state (θ_1, θ_2) the applied field should have the starting point in the origin of the coordinate system and the terminal point on the intersection of the equilibrium lines. If the intersection point is on the intersection of the stable regions, all the above mentions conditions will be fulfilled. It is important to remark that the radius of one of the two astroids is parallel to the equilibrium line associated to the other one and the angle they make with the abscissa is equal to the magnetization angle (Fig.). A key element in the study of critical points is the discriminant, its geometrical interpretation being a conic.

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