ADVANTAGES TO BE GAINED FROM THE SELECTIVE SPIN-WAVE RESONANCE CRITICAL ANGLES EFFECT

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ABSTRACT. We show that the exchange constant and surface anisotropy constants of a thin ferromagnetic film can be determined by measuring the critical angles at which the successive spin-wave mode peaks vanish.

Over 25 years ago, the effect of *total* critical angle was discovered[1-4] in spin-wave resonance (SWR) consisting in the vanishing of all but the first mode peak at a well-defined orientation φ_c of the external magnetic field with respect to the normal to the film surface. Later, an effect of *selective* critical angle has also been found[5,6], consisting in the selective vanishing of the peaks, each n-th peak vanishing at a different angle φ_c^n. The two effects are mutually independent and are accessible to an interpretation both on the Volume Inhomogeneity (VI)[1-4,6] and the Surface Inhomogeneity (SI)[7-10] models. Our present consideration concern the latter.

The significance of the total critical angle lies in the fact that it is the limiting angle upward of which the SWR spectrum exhibits the surface mode peaks[11,12,13]. This property is of cognitive and practical value as permitting to determine, in a simple way, the range of surface conditions favouring the occurrence of surface states in thin films. It is our aim here to draw attention to the fact that equally valuable data can be gained from observations of selective critical angles. In particular, we shall deal with the following aspects of the matter.

We restrict our considerations to the selective vanishing of odd modes, i.e. of peaks labelled $n=3, 5, 7, \ldots$ (we label the peaks in succession from the energetically lowest one onwards: $n=1, 2, 3, \ldots$). It is found[10] that this effect is undergone by modes with strictly defined wave numbers k_n. We propose to refer to them as quasi-Kittel modes, since their wave numbers obey the following quantization law:

$$k_n=(n-1)\frac{\pi}{L-1}, \qquad (1)$$

where L is the film thickness in lattice units. The foregoing information is of capital significance, as this is the only case in SWR when the exact value of the quantum number is known instantly for the inhomogeneous mode under investigation. This property of the selective critical angle can be put to profit in many ways, first of all as follows: Once the wave number k is known, the exchange constant can be determined with accuracy from the dispersion law (the method of its determination from measurements of peak separation, traditional in SWR, always involves unknown error for a lack of knowledge of the k_n's exact values). Another advantage from the study of selective critical angles regards the surface conditions, and reposes on the following relation[10], which has to be fulfilled by the surface parameters[8,9] at critical configuration:

$$a(k_n, \varphi_n)\, b(k_n, \varphi_n) = 1 . \tag{2}$$

By (2), the measurement of *two* consecutive selective critical angles permits the exact determination of both surface parameters. This is a simple procedure whereby information on the surface of a ferromagnetic film can be obtained.

Interest in the selective critical effect failed to grow on its discovery presumably because, in practice, rare are the cases when the following two conditions, necessary for the observation of the effect, are fulfilled simultaneously: 1° the volume anisotropy has to be of the appropriate type (i.e., of the type "producing" sufficiently great elliptical precession of the spins) and 2° the surface anisotropies have to satisfy the special asymmetry relation of Eq. (2). Also, the growing trend in surface magnetism studies, throughout the recent literature has diverted interest towards surface peaks in the SWR spectrum, and thus towards the total critical effect. The present Note is aimed at drawing attention to the fact that desirable surface data can be gleaned from the selective critical angles effect as well.

The problems outlined here will be dealt with in full detail separately[10] (including the selective effect for even peaks too).

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