PHYSICAL REVIEW B VOLUME 4, NUMBER 11 1 DECEMBER 1971

Origin of the Linear Term in the Expression for the Approach to Saturation in Ferromagnetic Materials*

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(Received 19 February 1971)

There has been confusion for many years over the origin of the a/H term in the expression for the approach to saturation, $M/M_s = 1 - a/H - b/H^2 + cH$, observed in many ferromagnetic materials. A calculation is presented which suggests that residual internal strain contributes significantly to this term. Internal strain has previously been thought to contribute only to the b/H^2 term. It is further suggested that the a/H term has been overemphasized and has validity only over a limited region of the H axis. The effect of internal strain is deduced from consideration of a problem concerning nonhydrostatic strains induced in slightly porous magnetic material subject to external hydrostatic pressure. A comparison with recent experimental work supports the calculation.

I. INTRODUCTION

There has been continued interest for many years in explaining the various terms which occur in the expression for the approach to saturation observed experimentally in many ferromagnetic materials:

$$\frac{M}{M_s} = 1 - \frac{a}{H} - \frac{b}{H^2} + cH \ . \qquad (1)$$

The cH term has been adequately explained in terms of paraprocesses. The constant in the b/H^2 term has been shown to be

$$b = \frac{8}{105}\frac{K^2}{M_s^2} + \frac{3}{5}\frac{\lambda_s^2 \langle \sigma_i^2 \rangle_{\text{av}}}{M_s^2} \ , \qquad (2)$$

where the first part is due to crystalline anisotropy,[1] and the second part, derived by Becker and Polley,[2] is considered to be the influence of internal strain on the approach to saturation.

The origin of the a/H term is not well understood. Calculations by Brown[3] have shown that dislocation effects can contribute to this term, while Néel[4] has concluded that stray fields due to nonuniform magnetization may bring about forces

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