energy increases linearly with the strain. This suggests that the equilibrium exchange and demagnetizing energy is about 2% of the induced anisotropy energy. This justifies ignoring the equilibrium exchange and demagnetizing energy in predicting magnetic behavior in the region of large elastic and plastic strain in YIG as was done by Royce[7] and Bartel.[10] It is realized that this statement need not hold true for all materials.

From the total thermodynamic energy, Equation (3.8), the equilibrium magnetization curve can be obtained. Thermodynamic equilibrium demands that

$$\frac{d\mathcal{E}}{d\theta} = 0.$$

This has two solutions;

$$\sin\theta = 0$$

and, ignoring exchange and dipolar energy,

$$2be\cos\theta + H_e M_s = 0.$$

Thermodynamic stability requires that

$$\frac{d^2\mathcal{E}}{d\theta^2} = 2be(\cos^2\theta - \sin^2\theta) + H_e M_s \cos\theta > 0$$

at the equilibrium solution. For the solution $\sin\theta = 0$, this implies that

$$2be + H_e M_s > 0.$$

Under shock induced anisotropy, this would always be the stable solution for material with negative magnetoelastic constants. For material with positive magnetoelastic constants, this solution becomes unstable at a nucleation field of $H_{nuc} = -2be/M_s$. The subsequent behavior is then given by the

second equilibrium solution. The predicted magnetization curve is

$$\frac{M}{M_s} = \begin{cases} 1 & \text{for} \quad H_e > -\frac{2be}{M_s} \\ -\frac{M_s}{2be} H_e & \text{for} \quad H_e < -\frac{2be}{M_s} \end{cases} \tag{3.9}$$

where $M/M_s = \cos\theta$ and $b = b_1$ for the <100> problem or $b = b_2$ for the <111> problem. The curves are shown in Figure 3.5.

3.2. Domain Theoretical Calculation (Polycrystal)

This development will proceed by considering the equivalent shock induced anisotropy effect in theoretically dense isotropic cubic polycrystalline ferromagnetic material. This will be accomplished from knowledge of the single crystal magnetic properties. Also, this should be a better approximation than the single crystal analysis of the preceding section to the magnetic behavior of commercial and natural material subject to this effect.

The prediction of a polycrystalline material property from its equivalent single crystal property is a problem confronted in many areas of physics. The approach, quite similar in every case, requires an averaging of the single crystal property for an arbitrarily oriented crystallite over all crystal orientations.[34] The complicating factor is that an arbitrary crystallite interacts, not only with the external forces, but also with other grains in the polycrystal. This grain-grain interaction can be mechanical (through stresses), electrical, or magnetic. In most cases, this complicated interaction is not known.

Examples are elastic constants, dielectric constants, magnetostriction constants, and conductivities. In each case basic assumptions concerning the grain-grain interaction must be defined before progress can be made. For