to the effect. The total energy expression for a ferromagnetic polycrystal, assuming interacting grains, takes the simple form

$$\mathcal{E} = Be \sin^2\theta - H_e M_s \cos\theta, \tag{3.11}$$

as in the single crystal cases with b replaced by B, since θ and ξ are complementary angles. Thus, thermodynamic equilibrium predicts a linear equilibrium magnetization curve for the interacting grain assumption,

$$\frac{M}{M_s} = \begin{cases} 1, & H_e > -\frac{2Be}{M_s} \\ -\frac{M_s}{2Be} H_e, & H_e < -\frac{2Be}{M_s} \end{cases} \tag{3.12}$$

intermediate between the extremes defined by the <100> problem and the <111> problem in the equivalent single crystal behavior.

3.2.2. Independent Grain Assumption

It is quite possible that the uniform magnetization field demanded by the previous assumption does not occur. The isolated single particle critical size within which a single domain exists for YIG is less than 1 micron. This size will increase for a bounded crystallite due to a substantial decrease in surface poles at the grain boundary, but not by more than an order of magnitude.[42] Also, the single crystal domain width predicted previously, Equation (3.8), was approximately 20 microns. The grain size of the material used in the present work ranged from 5 to 25 microns. This suggests that perhaps an intra-grain domain structure would nucleate in order to reduce magnetic poles which would otherwise collect heavily along grain boundaries.[42,44] This is usually the case for unstrained material and may possibly occur in the material behind the shock front. If an intra-grain domain structure occurred,

there would not be a prevailing magnetic field as was considered in the interacting grain assumption. In this case it would be more likely that each grain would distribute about some average depending on the orientation of its crystallographic axis with the external fields.

A simple consideration will show that, if independent grain conditions obtain, then the average magnetoelastic energy previously obtained in the interacting grain assumption is too high. The energy from the interacting grain assumption contained not only a part necessary to bring individual magnetic grains to their independent equilibrium positions, but also a part required to bring these magnetic grains into colinear alignment. Too large an induced anisotropy energy would then predict too much demagnetization.

The independent grain assumption is that each crystallite seeks equilibrium subject only to the requirements of the induced anisotropy field and the external magnetic field and independent of the behavior of neighboring crystallites. A rigorous approach to the averaging procedure would be to express the magnetization direction in the anisotropy energy expression, Equation (3.1), in terms of polar coordinates θ and ϕ. The total energy expression should then be minimized with respect to θ and ϕ for an arbitrarily oriented crystallite. The resulting magnetization projection along the direction of the applied field should then be averaged over all crystal orientations. This problem, which has been encountered previously in another context, cannot be solved explicitly for θ and ϕ and has not been completed.[40]

An alternate approach, in the spirit of calculations made by Lee,[46] is to write the average normalized magnetization,