The only progress through micromagnetic theory on the shock induced anisotropy effect has been made by Bartel.[11] He used an alternative approach, known as the Rayleigh-Ritz method, which circumvents direct use of Brown's equations. This method assumes a form for the final solution with a sufficient number of undetermined parameters. The total energy integral is then minimized with respect to these parameters.

His development assumed a uniform anisotropy field as would occur in single crystals for specific orientations or as would occur in polycrystals under the interacting grain assumption. By approximating the argument of the energy integral expression and by considering first harmonics in the assumed Rayleigh-Ritz solution and corresponding magnetostatic potential, he was able to draw conclusions about domain size, nucleation field, and subsequent deviation from magnetic saturation.

3.4. Porosity Effect

Previous observations suggest that the major structural defects capable of significantly altering the results obtained in earlier sections are nonmagnetic inclusions in the form of voids or impurities.[12] Porosity is characteristic of magnetic ceramics. Even the best hot pressing techniques are capable of producing garnets only to about 98% or 99% theoretical density while in ferrites 95% is a good number. This is probably characteristic of natural materials also.

Experiments by Wayne et al.[12] show that polycrystalline magnetic ceramics, when subject to hydrostatic pressure, show a strong dependence of magnetization on pressure. Their interpretation was that nonhydrostatic strains occuring in the vicinity of cavities created local magnetic anisotropy fields which produced local deviations in the magnetization and, hence, the observed effect. It has been suggested that this same effect might occur to some extent in the present shock induced anisotropy situation.

A calculation which relates the magnetization to the hydrostatic pressure and the porosity in the approach to saturation region of the magnetic material has been made.[48] This calculation is based on the assumption that the average behavior of an aggregate of cavities in the medium can be represented by the behavior of a spherical pore in an isotropic elastic continuum. The strain around a spherical pore in an isotropic elastic medium subject to external hydrostatic pressure deviates from hydrostatic strain. This deviation contributes to the anisotropy energy. The energy density at a distance r from the center of a pore of radius a has been calculated to be

$$\mathcal{E} = \frac{3}{4}\frac{B}{\mu} P \frac{a^3}{r^3} \cos^2(\psi + \theta) - H_e M_s \cos\psi \qquad (3.16)$$

where the first term is the induced anisotropy energy and the second is the interaction energy. θ is the angle between the field point and the applied magnetic field. ψ is the angle between the magnetization at the field point and the applied magnetic field. μ is the shear modulus and

$$B = \frac{2}{5} b_1 + \frac{3}{5} b_2 .$$

Equation (3.16) is derived in Appendix IV. By numerical methods, this expression leads to a prediction of the dependence of magnetization on P and H_e. Figure 3.6 shows this magnetic dependence on H_e for 3% porous YIG at two values of hydrostatic pressure.

The intention of this section is to make a simple estimate of the effect of porosity on the shock induced anisotropy effect for slightly porous material. In particular, 3% porous YIG will be considered since this material was utilized in these studies. It will be assumed that the correction to