instance, in the case of elastic constants,[35] two assumptions have been used. One assumption is that uniform strain[36] exists throughout the crystal. The other is that uniform stress[37] prevails. Experiment favors neither, usually being closer to an arithmetic average of the results of the two assumptions. The same assumptions are made in obtaining polycrystalline magnetostriction constants.[38,39,40,41] In this case experiment favors the assumption of uniform stress.

In the present problem, the state of strain behind a plane shock wave in a theoretically dense cubic polycrystal is assumed to be uniform. (See Appendix V.) The speculation involves the magnetic grain-grain interaction. This is a complicated many body interaction of current interest [42,43] about which little is known. In analogy to the previous examples, this development will define the extreme assumptions regarding the grain-grain interaction and then consider each individually.

One extreme is that material crystallites interact with sufficient strength to cause a cooperative, colinear alignment of the grains' magnetization vectors. The other extreme is that grain-grain interactions are negligible and that each grain individually seeks equilibrium determined by the requirements of the anisotropy field and external magnetic field. These assumptions will be called the interacting grain assumption and the independent grain assumption, respectively.

3.2.1. Interacting Grain Assumption

The interacting grain assumption will be considered first. This assumption was made by Royce[7,8] during pioneering work on the shock induced anisotropy effect and leads to a mathematically tractable averaging process.

Domain structure in a polycrystalline ferromagnet is usually on an intra-grain scale.[44] This is due to high crystal anisotropy energy and large angle grain boundaries which make continuous domains across grain boundaries energetically unfavorable. There are cases, however, such as in material subject to cold working, in which a high degree of crystal orientation allows an extra-grain domain structure.[4] In the present effect, the easy direction of magnetization is determined not only by the crystallographic axis but also by the direction of uniaxial strain. Thus, the effect of the shock wave is to create a condition of magnetic texture defined by the direction of uniaxial strain behind the shock wave. It would not be implausible to expect an extra-grain domain structure to nucleate after passage of the shock wave.

A further argument for this assumption follows by considering a spherical grain interior to a domain of uniform magnetization. The magnetization in this grain could deviate from this direction of uniform magnetization only by creating surface poles on the grain boundary. The energy associated with this is

$$\mathcal{E} = -\frac{4\pi}{3} M_s^2 \cos\theta .$$

In YIG, at typical shock stresses, this energy is of the same order as the strain induced anisotropy energy. Hence, there will be strong torques attempting to maintain uniform magnetization throughout the domain.

The following assumption simplifies the averaging process and creates a neat form for the magnetoelastic energy of a polycrystal. It is assumed that $\vec{M}\cdot\vec{H}_e$ is uniform throughout the field.

To proceed with the averaging process, the six dependent variables, α_1, α_2, α_3, n_1, n_2, and n_3, appearing in the energy expression will be expressed in terms of four independent angular variables as shown in Figure 3.4.[34,45] The direction cosines are related to the angular variables by