Demagnetizing Field in a Sample of Magnetically Ordered Medium

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Spatial distribution of a magnetization vector \( \mathbf{M} \) orientation in a volume of a open form sample of magnetically ordered medium depends on a local value of "internal" (Maxwellian) magnetic field \( \mathbf{H}_i \). This field \( \mathbf{H}_i \) does not have direct physical sense, as far as it is impossible to measure in the sample volume. However the field \( \mathbf{H}_i \) can be considered as formal value connected with an external field \( \mathbf{H} \) and a demagnetizing field \( \mathbf{H}_d \): \( \mathbf{H}_i = \mathbf{H} - \mathbf{H}_d \). The field \( \mathbf{H}_d \) of a sample is proportional to medium magnetization \( \mathbf{M} \) and is a function of demagnetizing factor \( |N|: \mathbf{H}_d = |N| \mathbf{M} \). In general case of arbitrary shape of a sample that is placed in arbitrary oriented field \( \mathbf{H} \) the demagnetizing factor is determined by sample shape and is a tensor of the second rank. Only samples in the form of ellipsoids of revolution those are made of homogeneous medium material and are placed in a uniform magnetic saturation field have homogeneous demagnetization field. For such samples it is obtained exact analytical expressions for demagnetizing factor [1]. For samples of no ellipsoidal shape the demagnetizing factor depends on not only the sample shape but also the material properties of the sample medium and magnetization distribution in the sample volume as well as supervision coordinates. The empirical values of the factor \( N \) for different forms samples are given in the form of graphs or tables [1]. In most cases the factors \( N \) are determined by experimental measurements of samples stray fields [2]. The field \( \mathbf{H}_d \) in the volume of periodic domain structure was investigated only theoretically [3].

Local optical exposure by linearly polarized radiation of a magnetically ordered medium with photomagnetic properties [4] leads to formation of a magnetization nucleus in the irradiated medium volume [5]. The photoinduced nucleation in volumetric sample of magnetically ordered m3m medium with negative (cubic) magnetocrystalline anisotropy energy always takes place in the field \( \mathbf{H}_i \) (at \( \mathbf{H}_i = \mathbf{H}_n \), where \( \mathbf{H}_n \) is a nucleation field [5]) and duration of the sample exposure is determined by the field \( \mathbf{H}_i \) value. Above-mentioned dependence opens up possibilities of direct experimental measurement of local value and/or spatial distribution of the demagnetizing field \( \mathbf{H}_d \) in a volume of arbitrary shape sample that is placed in arbitrary magnetic field \( \mathbf{H} \).

Local values and spatial distribution (at \( \mathbf{H} = 0 \)) and spatial distribution (at sample saturation state) of demagnetizing field \( \mathbf{H}_d \) are obtained experimentally in a volumes of the sample domain structure (at \( \mathbf{H} = 0 \)) and uniformly magnetized sample respectively. All results where obtained at local irradiation of single crystal (110) – plates of ferrite – garnet \( Y_3Fe_{49.6}Si_{0.4}O_12 \) at \( T = 77 \) K.