Nonlinear analysis of the magnetic liquid free surface deformation in 3D space

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The nonlinear analysis of the magnetic liquid free surface deformation under the influence of the static vertically oriented magnetic field produced by a pair of Helmholtz coils in a 3D space is presented in the article. The hexagonal pattern of peaks resulting from the Rosensweig or normal instability occurs when the magnetization of the magnetic liquid exceeds the critical value. To predict the amplitudes and distance between peaks in the pattern, nonlinear analysis with employed higher order terms in the mean curvature expression of the free surface should be performed. The computational strategy presented in the article is divided into two stages. In the first stage, the magnetic field in the 3D space is calculated by the FEM based software Opera Field, while the second stage is devoted to determining the surface profile by minimizing the energy functional using a differential evolution algorithm in Matlab. The amplitude of the central spike and wave number have been computed for the various values of the excitation magnetic field.

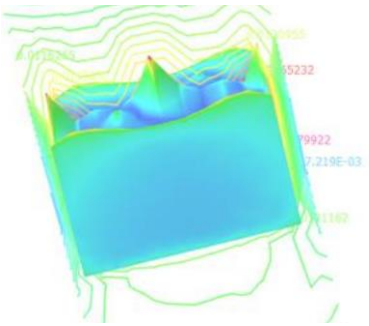

Figure 1. Magnetic field in the center of the single spike.

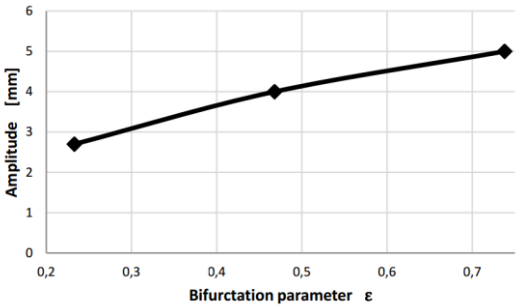

Figure 2. Height of the central spike above the reference level.

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