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Developing an experimental system to study the Magnetic Levitation Force of High-Temperature Superconductors (HTS)

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Abstract – In this work we present our results related to the construction of an experimental station to measure the levitation force associated to high-temperature superconducting materials, as well as the numerical results obtained from computer simulations. The numerical program is based on the classical critical state model and allows us to process and analyze the experimental data obtained from the built station. The experimental setup uses a special sensor that measures the levitation force produced between a permanent magnet and a superconducting sample. We are able to calculate the profiles of the density of current and the magnetization curves for superconductors in the form of an infinite bar. We also show here the calculation of the levitation force between the permanent magnet and the superconducting sample, both with finite cylindrical geometry. The results from both numerical simulations and experimental data are in perfect agreement with those published in the literature.

Soon after the discovery of high-temperature superconducting materials (HTS) there was a great interest in studying the levitation force between an HTS sample and a permanent magnet (PM). To do this, we have prepared HTS pellets of composition $YBa_2Cu_3O_{7-\delta}$ (Y123) by following the polymeric precursor method (Pechini). This chemical route allows us to obtain polycrystalline samples of high homogeneity with almost no secondary phases. The quality of samples and their chemical composition, as well as the formed phases, were analyzed by the x-ray diffraction (XRD) technique and Rietveld analysis, and also by scanning electron microscopy (SEM). We have also performed the physical characterization of samples by measuring the AC magnetic susceptibility and resistivity, both as a function of the absolute temperature. The experimental station consists of a table to make the movements in the three coordinates (XYZ), numerically controlled by very sensitive step-motors. This mechanical system is located above a liquid nitrogen reservoir to cool down the superconducting sample (Figure 1). The experimental setup uses a very sensitive special sensor that measures the levitation force[1] produced between the permanent magnet (made of NdFeB or SmCo) and the HTS sample[2]. The versatility of our system allows measuring samples with different compositions and geometries. The numerical program to obtain the levitation force is based on the classical Bean critical state model[3] and allow us to process and analyze the experimental data obtained from the built station. We are able to calculate the profiles of the density of current and the magnetization curves for superconductors[3]. From this, we can perform the calculation of the levitation force between a permanent magnet (PM) and a superconducting (HTS), both with finite cylindrical geometry[4] (Figure 2). The performance of the experimental system, as well as the quality of numerical results, allow us to successfully study the levitation force associated to HTS materials.

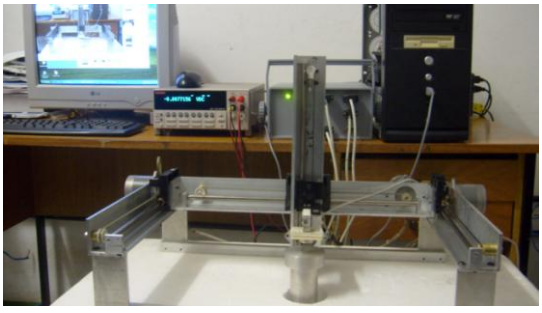

Figure 1: Picture of the levitation experimental setup

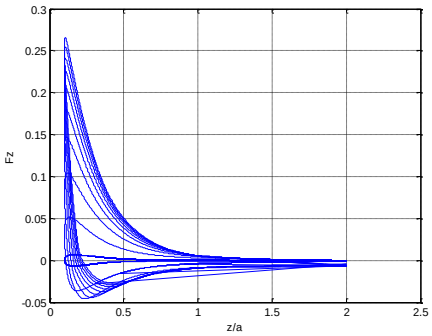

Figure 2: Levitation force as a function of z coordinate for different b/a ratios: 0.05 (inner curve), 0.1,0. 2,0. 4,0. 6,0. 8 and 1 (outer curve).

References

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