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Measurement and understanding of magnetization in AC and DC fields and the determination of intragrain H_{c1} in high T_c $RBa_2Cu_3O_7$ superconductors

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Abstract. We present DC and low frequency AC magnetization measurements on various $RBa_2Cu_3O_7$ superconductors. We identify features intrinsic to these compounds, and establish the features originating from intergranular links in sintered pellets. The isothermal magnetization curves, and the temperature dependence of magnetization in field-cooled and zero field-cooled states are shown to be consistent with the calculations done following a recent extension of Bean's model. Low field anomalies predicted within this model are observed, and yield H_{c1} values of a few Oe. These values are shown to be consistent with the temperature variation of magnetization. A comparison is made with the other existing data and it is demonstrated that earlier quoted values of H_{c1} are gross overestimates.

Keywords. High temperature superconductors; lower critical field; magnetization curves; critical currents; AC methods; DC methods; hysteresis loops.

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1. Introduction

The lower critical field H_{c1} is a basic physical parameter of a type II superconductor and its value can be used to infer microscopic properties of the superconducting state. The textbook definition of H_{c1} is the field below which there is a complete flux expulsion. When a magnetization measurement is made on a sample of macroscopic size, macroscopic shielding currents can be set up at $H > H_{c1}$ which will effectively shield the bulk of the sample from the magnetic field (Bean 1962, 1964). It is the experimentalist's problem to find ways to distinguish this macroscopic shielding (which, though not ideally total, may appear total within the experimental error) from the thermodynamic Meissner state and thus determine H_{c1}.

The magnetization measurements are usually made to obtain information about the extent of magnetic flux expulsion in superconductors. The magnetization curve of a superconducting sample is obtained by first cooling the sample to a given temperature in zero field (ZFC) and then gradually raising the externally applied field H_e. Upto the field H_{c1} (ignoring the demagnetization correction) the screening currents are set up at

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