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Design and performance of a cryo-flipper using a YBCO film

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Abstract

It is well-known that the Meissner effect in superconducting materials can be used to provide a well-defined non-adiabatic magnetic field transition. This can be utilized to produce a highly efficient neutron spin flipper that is suitable for use on a white beam. However, these devices typically utilize niobium and hence require continuous use of liquid helium in order to maintain the device temperature.

The use of high Tc materials removes the need for cryogens and has been explored previously [1]. Here we present a design using a 350-nm-thick YBCO film capped with 100 nm of gold on a 78 x 100 x 0.5 mm sapphire substrate (Theva, Germany). We discuss the design and performance of this device. The apparatus is compact (~300 mm in length along the neutron beam), consisting of an oxygen-free high-conductivity copper frame, which holds the YBCO film and is mounted to the cold finger of a closed-cycle He refrigerator. The part of the vacuum chamber, where the YBCO film is located, is ~ 5 cm wide, which allows us to minimize the distance from the film to the magnetic guide fields. This distance is ~30 mm on each side. The details of the guide field design are also discussed. In this design, the maximum neutron beam size that can be used is 45x45 mm2 and we can easily switch from a vertical to a horizontal guide field on either side of the YBCO film. Preliminary data of the cryo-flipper in operation at the SESAME beam line at LENS (Low Energy Neutron Source) are shown for neutron wavelengths between 5-15Å.

A discussion of the guide field modeling will be presented with emphasis on producing a uniform field profile at the YBCO film. We also discuss the possibilities for further scaling of the device to larger beam sizes and an even smaller footprint.

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[1] M.R. Fitzsimmons, M. Lütt, H. Kinder, and W. Prusseit, “YBCO films as Meissner screens in the control of polarized neutron beams – Observations and calculations”, Nucl. Instr. Meth. Phys. Res. A **411**, 401 (1998).