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Application prospects of multilayer film shields for space research instrumentation

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Abstract

We have studied the magnetic properties of multilayer film cylindrical configuration shields (MFS) based on NiFe / Cu. The studied samples were prepared by electrode position. MFS were constituted by alternating layers of NiFe and Cu, deposited on an aluminum cylinder with diameter of 4 cm, length of 13 cm and 0.5 cm thickness. The thickness of each ferromagnetic layer varied from 10 to 150 µm, and the thickness of Cu layers was 5µm. Five-samples in which the number of ferromagnetic layers varied from 3 to 45 and copper – from 2 to 44 were tested. The best shielding efficiency was achieved at the maximum number of layers and comprised about 10^2. Permalloy multilayer foil shield at the same total thickness has several times less efficiency in comparison with MFS. The description of a prototype of the charged particles telescope for space application is presented. Results of its testing regarding sensitivity to the constant magnetic field are described.

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Keywords: multilayer shields, constant magnetic field, telescope counters.

1. Introduction

Creating effective shields for protection against constant magnetic fields is a highly relevant scientific and technical challenge. This is confirmed by the fact that, for scientific purposes and various devices (sensors and electronic circuits, and etc.) sensitive to negative effect of constant magnetic fields, the shields are used widely. On

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the other hand, magnetic sources are increasingly used in scientific and applied researches. Some of them have magnetic field intensity up to several Tesla.

This task is especially acute in particle and astroparticle physics. For example in experiments on accelerators of elementary particles (LHC CERN, TevaTron FermiLab) where, for instance, PMTs, which are very sensitive to influence of magnetic fields, are combined with superconductor magnets. In the experiments constant magnets are also often used on spacecraft as part of scientific equipment (Magnetic Spectrometer PAMELA).

Theory and practice of magnetic shields creation have been developing for many decades, and as a result, a conclusion has been reached that multilayer magnetic shields have considerable advantage in comparison with monolithic shields. However, it is technologically difficult to create such shields for protection of objects with complex geometric configuration. The technology for electromagnetic shields manufacturing based on multilayer film electro-deposited structures was created in the Scientific and Practical Materials Research Centre of National Academy of Science of Belarus. This technology allows eliminating these disadvantages and creating magnetic film shields with high shielding properties. This work is devoted to investigation of shielding characteristics of such shields, research of their efficiency with Russian PMT-85 and estimation of prospects of these shields application in the equipment for space purposes.

It has long been demonstrated that multilayer shields have shielding factor significantly higher than monolithic shields at the same amount of magnetic-soft material. However producing a multilayer shield from foil for a shielding element of complex configuration is difficult. Using the electro-deposition technology significantly simplifies the creation of such shields and allows a high degree of shielding from constant magnetic fields and electromagnetic radiation [1, 2].

In this case, it is possible to shield the elements of complex configuration or small dimensions. When the number of magnetic material layers is 45 and the thickness of each layer is10μm, and they are separated by layers ofcopper5μmeach, the shielding factor is greater than 100 [3].

2. Multilayer film magnetic shields for protection of PMT

Initially, measurements were made of the influence of the magnetic field on the amplitude of the output signal from an unshielded PMT-85 when it was exposed to a magnetic field, along three mutually perpendicular axes of the PMT.

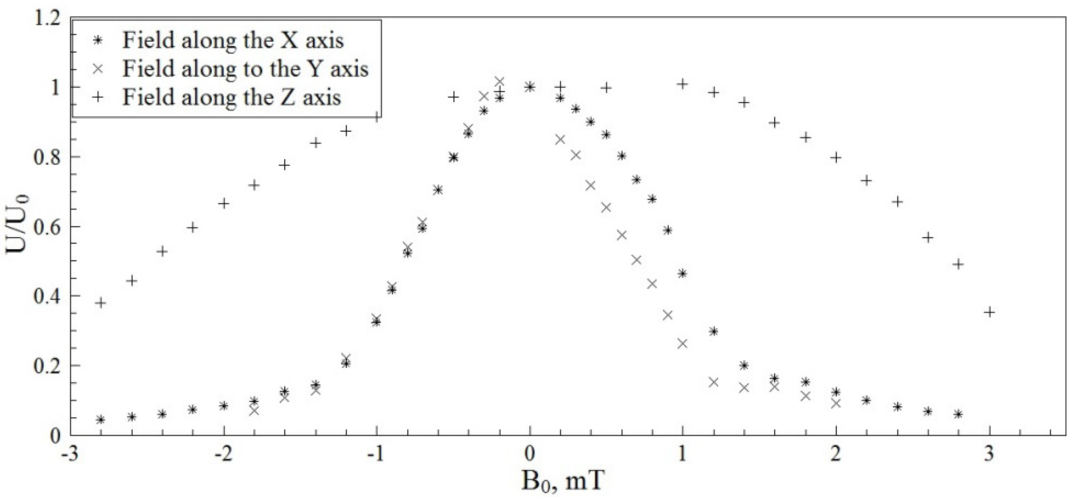

Fig. 1. Dependence of the relative amplitude of the output signal of an unshielded PMT-85 on the magnetic field along the axes (X, Y, Z). Axis Z is parallel to the cylindrical shield. Experimental errors are located within the experimental points.