The theoretical and practical limit of the residual field inside magnetic shielding

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Enclosures made of highly permeable and highly conductive materials are used as a passive shield to reduce the static magnetic field and magnetic disturbances for fundamental physics experiments and biomedical diagnostics. The absolute magnetic field inside strong shields is limited by the magnetization of the shielding material itself. The common way to decrease the field of the shielding walls is equilibration in the present background field. Based on the hysteresis behavior of the shielding material during the equilibration process, a method to calculate the limit of the residual field inside shields is introduced. The comparison of the theoretical limit with the dynamic simulations of the equilibration process shows that the coil arrangement can improve the residual field obtained after the same number of cycles. This is proved experimentally in a conventional 3 layer magnetically shielded room where the residual field is lowered close to the resolution of the SQUID based absolute field detector by the introduction of distributed demagnetization coils. A reproducible residual field of less than 130 pT within a central cube of 0.5 m length was achieved. This is the best residual field ever measured in such a volume.

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