ORAL TALK

Accounting Material Imperfections in the Design of Halbach Magnets

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The performance of permanent magnets is limited not only by their design [1], but also by their high sensitivity to temperature and imperfections of magnetic materials. Whereas the first issue, for example, can be solved by temperature stabilization of environment, the issue of material imperfection will always be an individual problem in each magnet construction. This is because there are always production defects which lead to the variation of the magnetization of individual magnet block by 0.1–5% and additionally deviation of the magnetization angle up to 0.9° compared to ideal magnets [2]. These are the reasons why real magnet systems have always strongly reduced homogeneity when compared to calculations and simulations.

In this work we demonstrate an experimental method for the improvement of the magnetic field homogeneity in Halbach array by taking magnet material imperfection into account.

In Fig. 1b the proposed Halbach array composed of 8 elements is showed. Its dimensions are 40×40×102 mm and weight is 0.6 kg. The filed homogene-

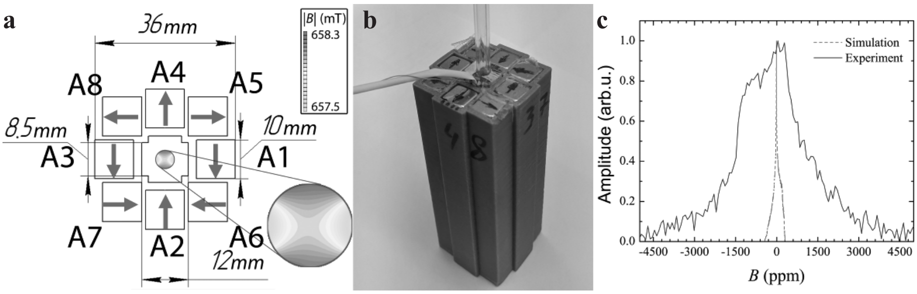

Fig. 1. The Halbach magnet consisted of 8 elements: **a** the drawing and the calculated field map in the sample volume, **b** the photograph of the assembled magnet, **c** the cal-culated (ideal infinite magnets) and experimentally determined magnetic field distribution in initial configuration.

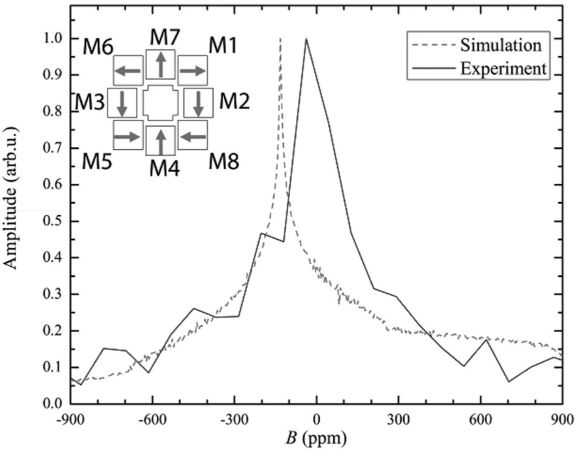

Fig. 2. Computed with neglected angular deviations and measured field distributions in Halbach magnet configuration with the best homogeneity of the magnetic field.

ity was evaluated on a water sample in the working volume with a diameter of 4 mm and a height of 10 mm. The NMR measurements were performed on a home-built pulsed spectrometer [3].

As can be seen from Fig. 1c the experimental field map (solid line) significantly differs from those predicted by the simulation for ideal magnets (dashed line).

The proposed method of field homogeneity improvement relies on determination of the magnetization magnitude for individual magnet blocks based on NMR field measurements in a simplified system which in our case consists of 4 blocks (A1, A2, A3, A4 positions in Fig. 1a). Then a set of configurations with highest homogeneities can be found from simplified field maps simulations of all possible configurations or by applying sophisticated optimum search algorithms if the number of blocks is large. Finally, the residual effect of angular magnetization deviations can be reduced by experimental selection of the best configuration from the set found on simulation step.

By applying the described method we have found the best configuration (Fig. 2) in which the average value of the magnetic field and a half-width were found to be 598.0 mT and 226.9 ppm, respectively. These parameters are sufficient for solid state NMR relaxometry measurements.

1. Müller K.-H., Krabbes G., Fink J., Gruß S., Kirchner A., Fuchs G., Schultz L.: J. Magn. Magn. Mat **226-230**, 1370–1376 (2001)
2. Blümler P., Casanova F.: Mobile NMR and MRI. Chapter 5. hardware developments: Halbach magnet arrays: Royal Society of Chemistry 2016.
3. Kuzmin V., Bogaychuk A., Nekrasov I., Safiullin K., Salakhov M., Alakshin E., Klochkov A., Tagirov M.: Magn. reson. solids **21**, 1–7 (2019)