Measuring the orthogonality in Helmholtz coils

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Introduction

The use of Helmholtz coils in two or three axes is increasing in diverse fields of Physics and Engineering. Also increases the need for to reduce the orthogonality error between the magnetic axes as well as for to be able to determine the magnitude of this error in a given coil-set.

Being aware of these needs and not having found in the literature no practical method applicable, we have developed a simple procedure for measuring the angles among the magnetic axes of a Helmholtz coil-set, to be able in that way to determine the maximum orthogonality error of the coil-set.

This procedure allows us now to check in a very direct way whether our standard coil-sets comply with the specified maximum error of ± 0.2º . This also allows us to offer coil-sets, both standard and specials, with specifications on request for the orthogonality, for example of ± 0.1º, which may include up to ± 0.05º in some cases.

The procedure is based on the magnetic coupling between two pairs of Helmholtz coils and, therefore, the mutual inductance in between these pairs. We have determined the relationship between mutual inductance and the orthogonality error, so that we can now know this by measuring that.

Procedure

The mutual inductance (*M*) between two concentric Helmholtz pairs is maximum when the angle between its magnetic axes is zero. Moreover, *M* will be zero when the angle is 90º (orthogonal axes). See Fig. 1 for some examples.

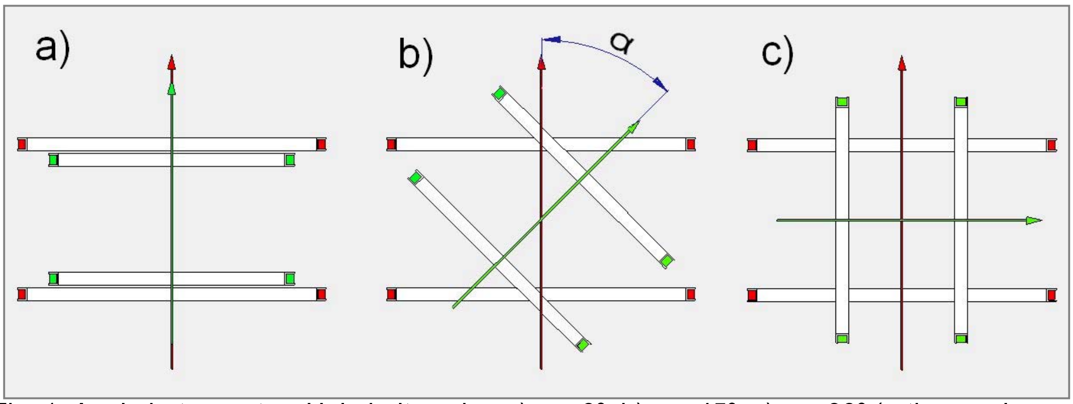

Fig. 1: Angle between two Helmholtz pairs: a) α = 0º; b) α = 45º; c) α = 90º (orthogonal axes).

To check the orthogonality of a coil-set of three axes, denoted X, Y and Z, we should perform the respective checks between the following three pairs of axes: XY, XZ and YZ.

Our goal was to be able to measure small values of *M* to correlate with small differences of angle between the axes with respect to 90, which has finally been achieved.

Using methods partly theoretical and partly empirical, it was possible to us to find a formula that relates the mutual inductance with the orthogonality error between whatever two Helmholtz pairs, so we can know what orthogonality error corresponds to any measured small value of *M*.

In the Fig. 2 it is a device used to determine some parameters of the formula.

Fig. 2: Apparatus to measure *M* in function of angle, on pairs of about 300-mm in diameter.

For the moment the procedure is fully applicable to small and medium size coil-sets, to about 600-mm in diameter, because with the size also increase some difficulties for measurement. Yet it is precisely in these small and medium sizes where the procedure is more useful, because in larger coil-sets the errors, or defects, introduced in its geometry during manufacture, has a smaller effect on the orthogonality of the magnetic axes.

The procedure has the added advantage of being able to be used while making corrections to the geometry of the coil-set when its construction technique allows, for example by inserting supplements, or shims (shimming), to bring the error within certain limits. This can be done in most of our coil-sets.

The procedure is also applicable in Helmholtz coils square and rectangular.

This is preliminary and summarised information. We may release more details in the near future, by publication in a specialised media of a technical article that is in preparation.

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