Magnetic levitation in neutrino physics: Calculate and build a demonstrator

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Neutrino mass measurement

Neutrinos were thought to be massless but recent experiments show that nuclear beta-decay provide an approach to directly measure the neutrino mass even though very small.

AMBER apparatus is used to measure end point energy in beta-spectrum.
At the end point energy there will be a discrepancy between maximum electron energy and total energy corresponding to the mass of neutrino produced.

Objectives

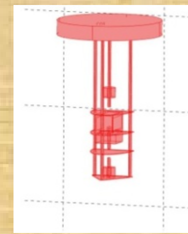
-Calculate magnetic fields in a specific configuration to characterize and achieve magnetic levitation using a commercial program, COMSOL.

- Calculations should serve to build a demonstrator and try to improve the existing magnetic levitation set-up.

COMSOL

COMSOL is a simulation package that has application modes in many different areas of Physics. The manuals provide an excellent guide to self-familiarise . Working through the examples enhance the understanding.

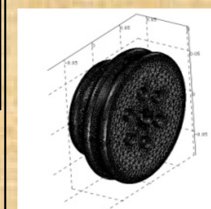
Model simulation



Geometric modelling: An integrated CAD drawing tools used to create and define geometries in 2D,3D.(Fig1)

Fig1. A geometric model of the AMBER apparatus

Physics settings: adjusted according to the required physics of model to give appropriate outcome. Boundary conditions and Subdomain settings are most important.



Meshing: Dividing the geometry into mesh elements for computation.(Fig2)

Fig2. Mesh geometry of a pulley

Solving: integrated PDE techniques are used to process the model.

Post-processing: Only half the work is done once the model is solved. Post-processing the result is how the simulation can be communicated visually and mathematically to the community.(Fig3)

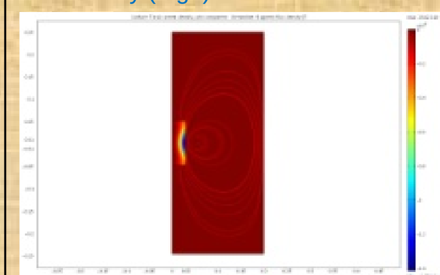


Fig3. Surface plot of Eddy current and its surface effect

Demonstrator building

A framework to support the apparatus was designed and built fixed on a box containing the electronics.
The most time-consuming part was the making of the electronic circuit which was somewhat robust but complex.
Magnets of 1.38T(2 cylindricals) and 1.28T(ball) were used.

Results and discussion

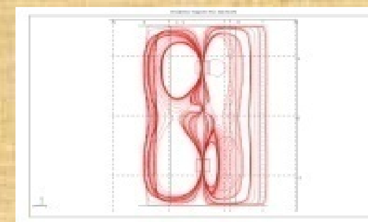


Fig 4. Streamline representation of the magnetic field

Despite a complete simulation of the magnetic field (Fig4) in the magnetic levitation configuration achieved, the lack of in-depth understanding, unstabilities in computation and insufficiency of time prevented further investigation to improve the existing AMBER set up.

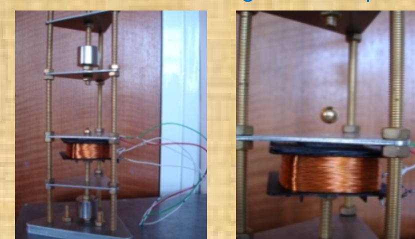


Fig 5,6 Demonstrator with successful magnetic levitation

A demonstrator was successfully built (Fig5,6) that achieved magnetic levitation. There were a few flaws in the design which can be further improved to fulfill its capability as an attraction for public purpose.

Acknowledgement

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