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COMSOL CONFERENCE 2014CURITIBA

Design of an Electrodynamic Levitation System with COMSOL Multiphysics® Software

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Summary

Introduction

- The levitation phenomena, besides its fascinating appearance, has found important applications in several areas:

1. Microgravity systems
2. Material sciences
3. Transportation
4. Industrial solutions
5. Pharmaceutical applications

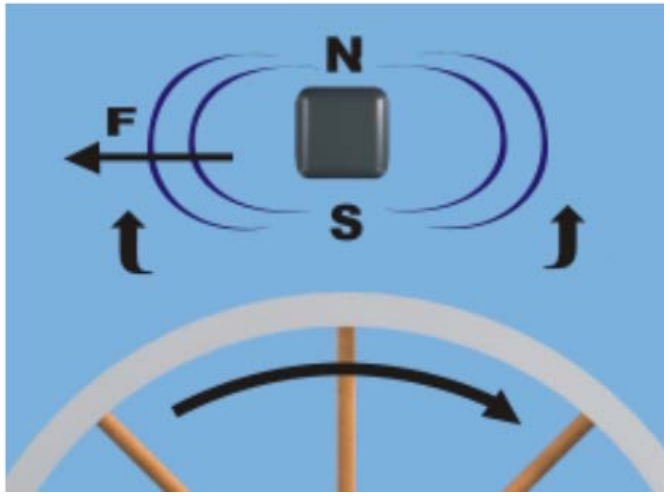
Introduction

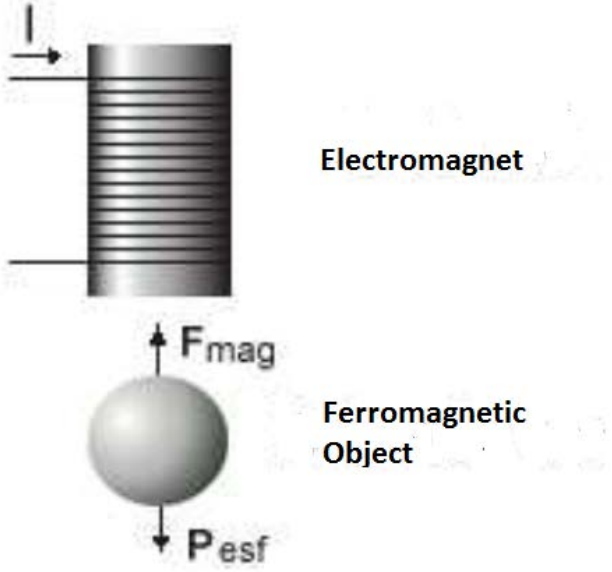
- These applications can be achieved by several techniques:

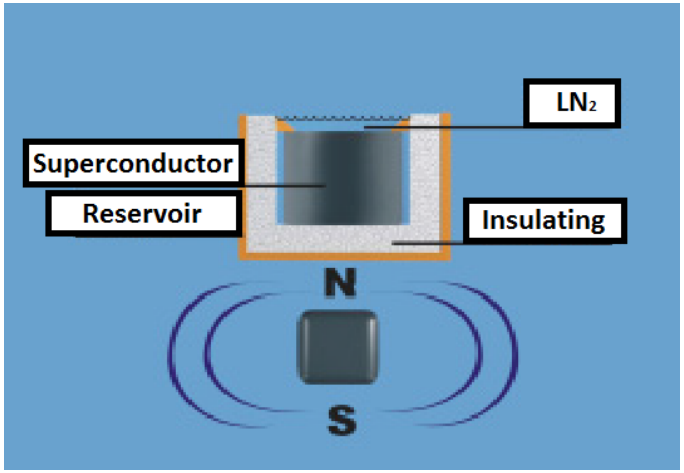
1. Aerodynamic
2. Acoustic
3. Optical
4. Electrostatics
5. Magnetic Levitation
6. Radio-Frequency

Magnetic Levitation

- Electrodynamic Levitation (EDL)
- Electromagnetic Levitation (EML)
- Superconducting Magnetic Levitation (SML)





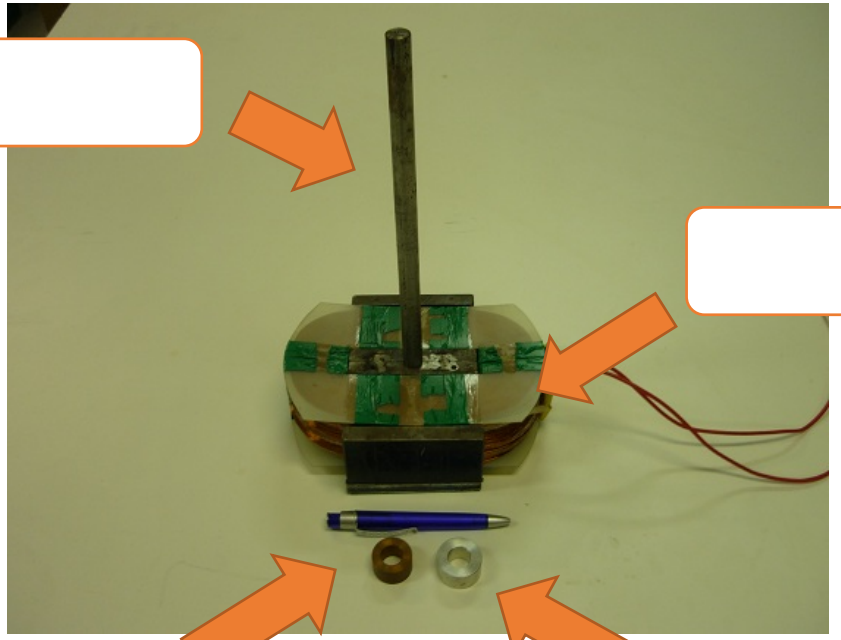


Objectives

- Development of an electrodynamic levitation experiment for engineering education, that can be supplied by the grid voltage.
- Training of students based on a multidisciplinary experiment that combines diferent subjects (electromagnetism, mechanics, control), experimental work and numerical simulation.

Electrodynamic System

	Mass	Dimensions
Aluminum	23,5 g	3,1 x 1,6 x 1,9 cm
Copper	56,9 g	2,8 x 1,6 x 1,9 cm



Iron Core

Copper Coil

2500 turns
0.65 mm²

Copper Ring

Aluminum Ring

Experimental Tests

Levitation observed:

- Aluminum ring: 250 V
- Copper Ring: 450 V

At 450 V and 60 Hz:

- Levitation of aluminum: 9.9 cm
- Levitation of copper: 6.0 cm

FEM Modeling

- Complex geometry
- Non-linear effects on ferromagnetic material
- Skin effect on conductors
- Electric and Magnetic boundary conditions

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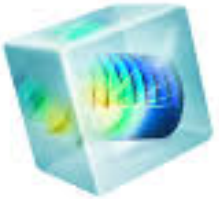
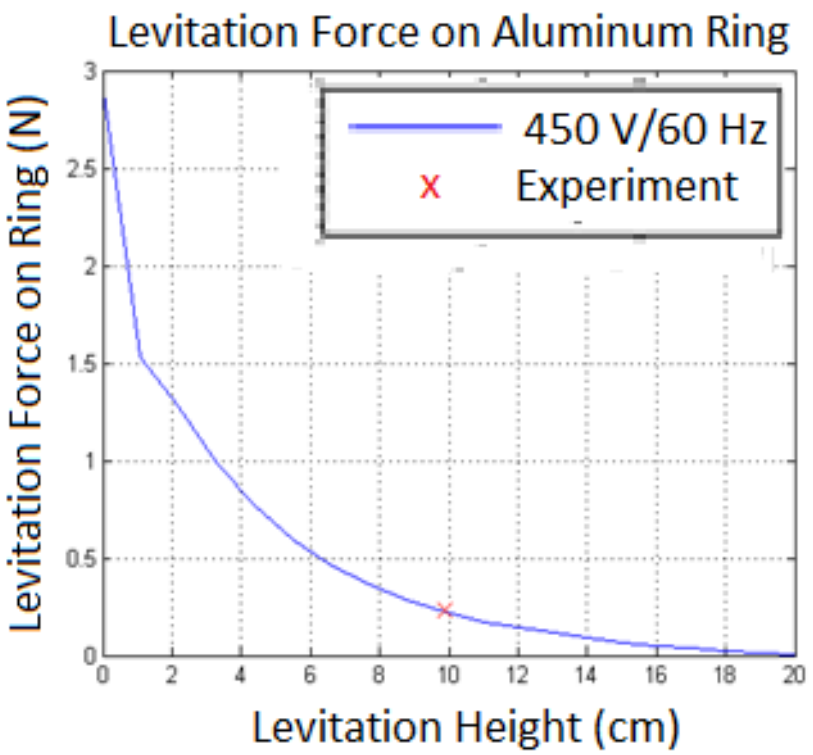
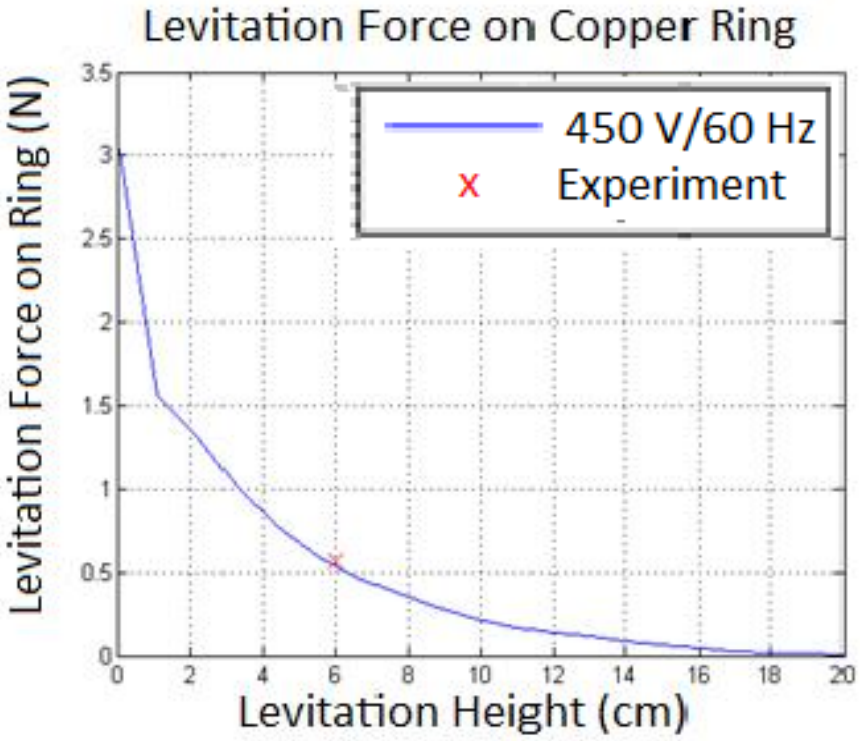


FEM Modeling

- 2D Axisymmetric
- Magnetic Physics Interface – AC/DC Module
- Muti-turn Coil Domain
  - V_{coil} = 450 V
- Aditional Ampère's Law (*μ = 10000)*
- Force Calculation
- Frequency Domain (*f = 60 Hz*)

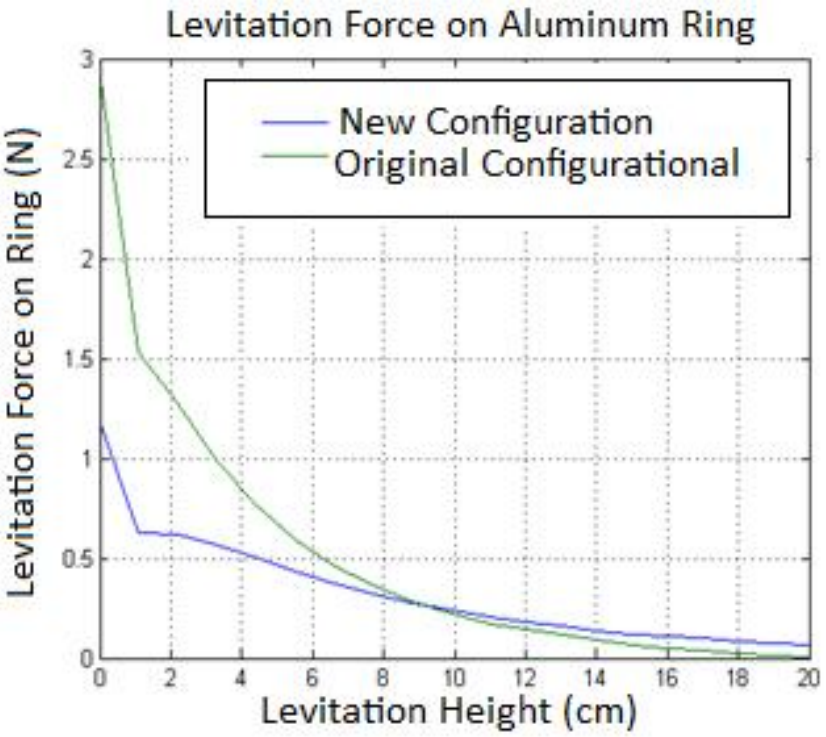
FEM Simulations

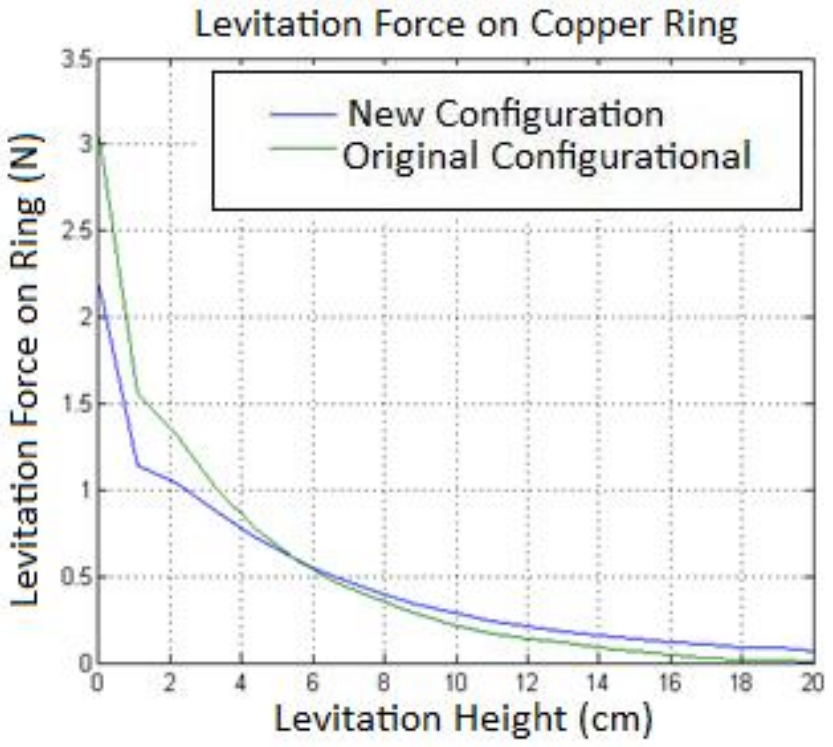




FEM Simulations

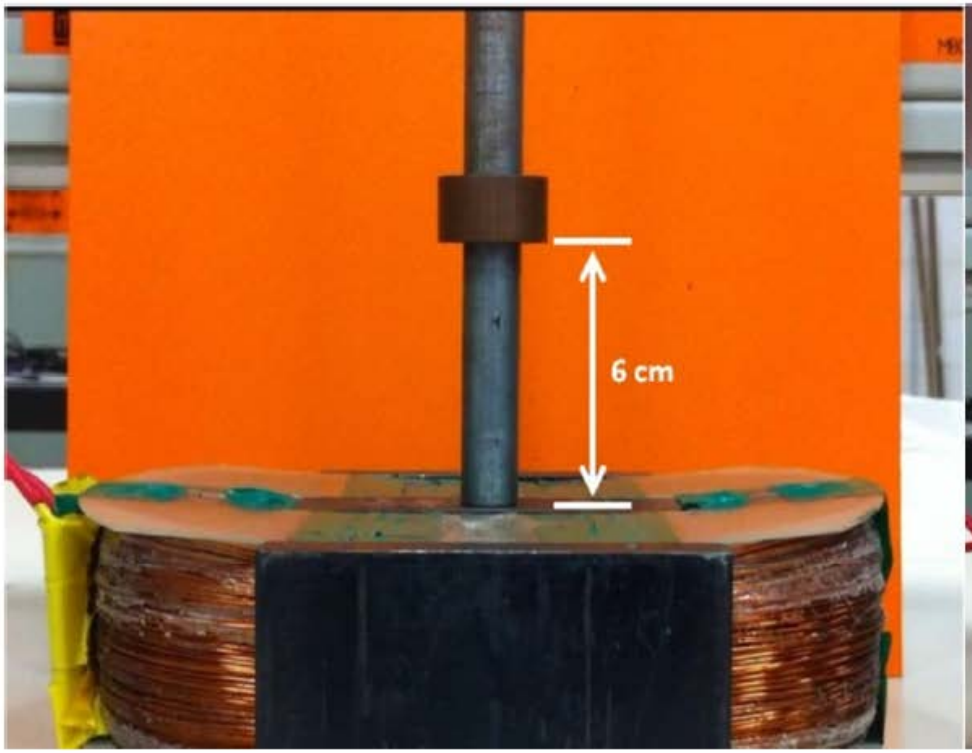
- To achieve levitation at 127 V:
- New Configuration: 127 V, 15 Hz

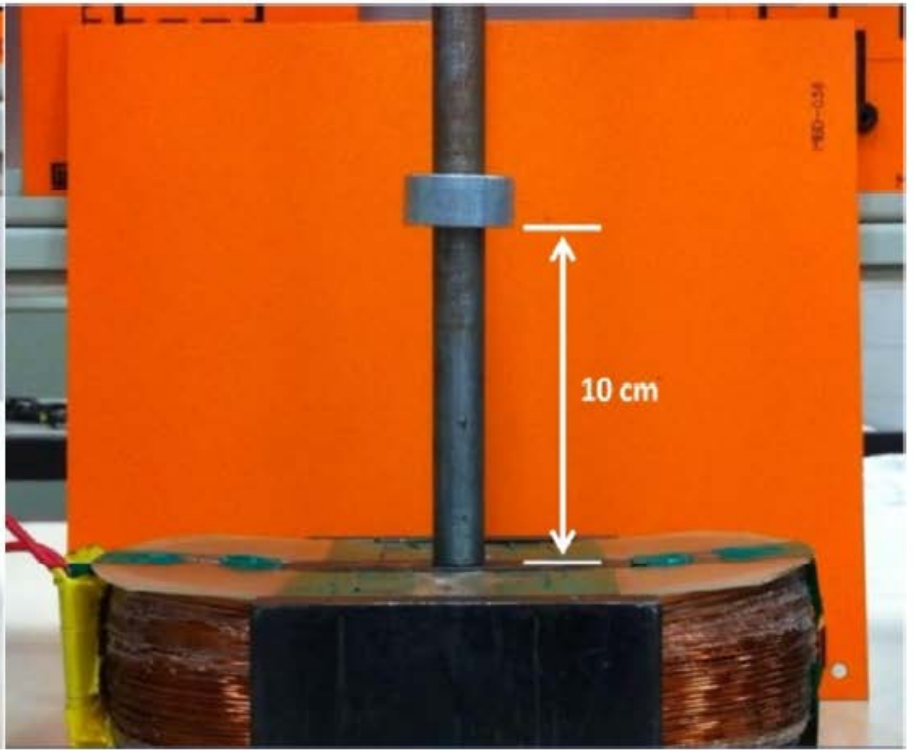




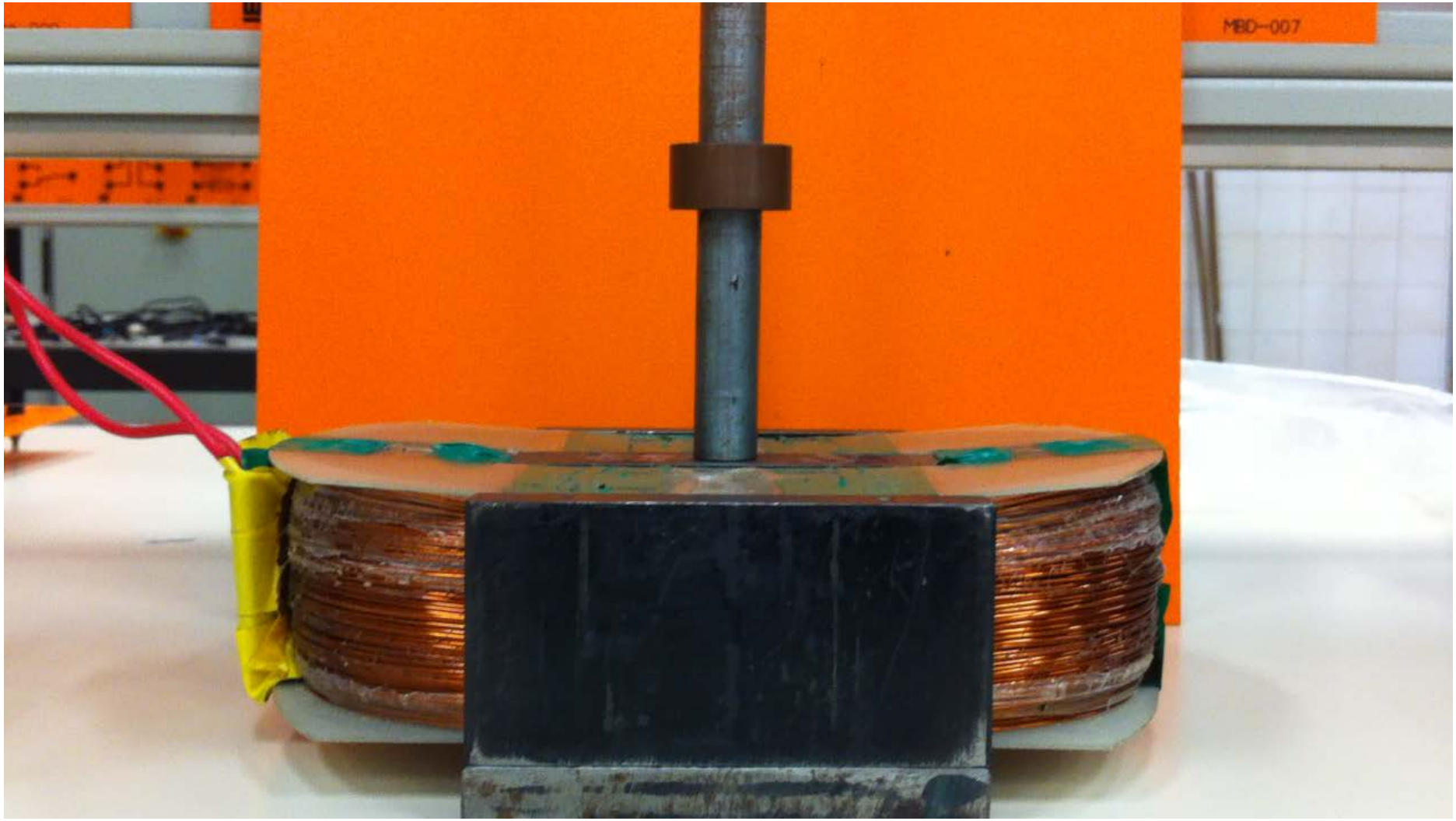
Results

- At 127 V and 60 Hz

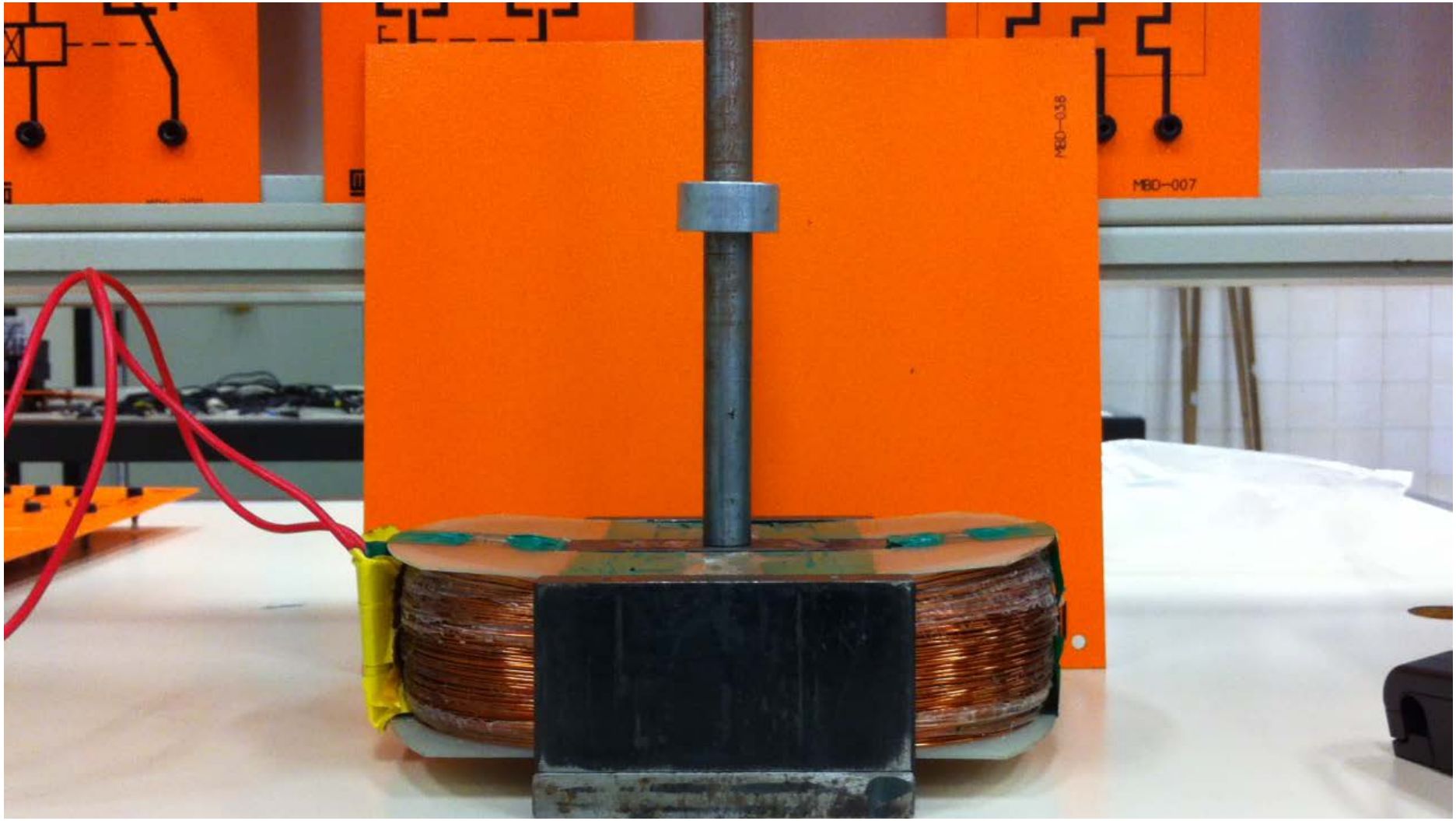




Results



Results



Conclusions

- COMSOL Multiphysics® is an excellent tool to simulate and design electrodynamic levitation systems.
- This electrodynamic levitation system is an good experiment for introduce undergraduate students to advanced topics of research (Finite element method and magnetic bearings).

Acknowledgements

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Thank you for your attention!