## ABSTRACT

This thesis investigates the crucial role of higher-order magnetic fields and non-linear optics in the stability and performance of particle accelerators, focusing on the Large Hadron Collider (LHC) at CERN. The control of non-linear optics, which deals with the interaction of charged particle beams with complex magnetic fields such as sextupolar, octupolar, decapolar, and so on, is essential for managing beam dynamics. The LHC, as the world's most powerful accelerator, provides a unique opportunity to study these high-order effects, serving as a testbed for future accelerator designs.

These higher-order fields significantly affect the beam's dynamic aperture and lifetime, especially at injection energy, where precise correction of magnetic field errors is required. Managing these challenges is not only vital for optimizing LHC performance but also for guiding the design and operation of next-generation machines.

A key contribution of this work is the development of correction methods, based on a response matrix approach, for Resonance Driving Terms (RDTs), a critical factor in beam lifetime and dynamic aperture limitations. New corrective strategies for RDTs have led to notable improvements in beam lifetime and dynamic aperture at both injection and top energy operation. This thesis also addresses the discrepancies observed between experimental measurements and models of beam observables.

These findings highlight the importance of precise modeling and correction of non-linear magnetic fields, offering insights that will benefit both the LHC and future high-energy particle accelerators.



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PhD Thesis – LHC Effective Model For Optics Corrections – Maël Le Garrec

# LHC EFFECTIVE MODEL FOR OPTICS CORRECTIONS

Measurements and corrections of high-order non-linear optics


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