

# ERASMUS MUNDUS JOINT MASTER IN NUCLEAR PHYSICS

Academic Year 2026/2027

## MASTER THESIS PROPOSAL

TITLE: Development of an Hamiltonian optics propagation code

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### ABSTRACT

**Context:** Ray propagation in optical systems in the Hamiltonian formulation ( $H = -\sqrt{n^2 - p_x^2 - p_y^2}$ ): each optic element is a Lie map computed as a Truncated Power Series Algebra (TPSA). The Generalized TPSA (GTPSA) developed for MAD-NG at CERN allows maps to arbitrary order with parameters which is ideal for aberration analysis.

**Objective:** Develop a Python code based on Hamiltonian optics / Lie algebra / GTPSA to simulate devices with multiple optic elements and compute associated aberrations.

**Work program:**

1. Bibliography on Hamiltonian optics and Lie methods (Dragt, Forest, Berz).
2. Implementation of Hamiltonian and maps for drift, refraction, mirror, and compound systems.
3. Composition of maps via GTPSA to obtain system map to higher order and extraction of Seidel aberrations (spherical, coma, astigmatism).
4. Validation against either analytical formulas or ray-tracing (Zemax/COMSOL).

**Profile:** Solid Python required. Notions of C++, Mathematica and Hamiltonian mechanics appreciated but not mandatory. Curiosity for computational physics and optics.

**Environment:** LPC Caen (Virgo group). The candidate must contact the supervisor before choosing this internship.