Proposition de stage – Année 2027

Niveau du stage : M2

Durée du stage : 4 mois

Ouverture éventuelle vers un sujet de thèse : Oui (ou « Projet Long de Recherche » pour l'ENS)

Type de financement de thèse envisagé : Concours de l'école doctorale PHAST

Responsable du stage : Florian NORTIER

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Domaine Scientifique de la Doua – Bât. Paul Dirac
4 rue Enrico Fermi – 69622 Villeurbanne Cedex - France

Equipe d'encadrement : Théorie des 2 Infinis

Thématique : Physique théorique des particules élémentaires

Intitulé du stage : *Un boson de Higgs léger à la lumière du mélange ultraviolet-infrarouge*

Description du travail demandé : Voir page 3 (en anglais)

Modalités de candidature :

Les étudiant.e.s intéressé.e.s adresseront leur candidature par e-mail, en transmettant :

- une lettre de motivation,

- un curriculum vitæ académique détaillé,

- les relevés de notes depuis la dernière année de licence ou équivalent.

Conditions de recevabilité :

Les candidat.e.s devront avoir suivi des cours de théorie quantique des champs et de physique des particules de niveau Master 2 avant le début du stage.

Processus de sélection :

Les candidat.e.s présélectionné.e.s seront invité.e.s à un entretien individuel d'ordre informel (en visioconférence ou en présentiel), préalablement au choix définitif.

Internship offer – Year 2027

Internship level: M2

Duration: 4 months

Possible PhD follow up: Yes (or "Projet Long de Recherche" for an ENS student)

Proposed PhD funding type: Selection by PHAST doctoral school

Supervisor: Florian NORTIER

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Address: IP2I Lyon – Bureau 339
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4 rue Enrico Fermi – 69622 Villeurbanne Cedex - France

Mentoring team: Theory of the 2 Infinities

Research field: Theoretical Elementary Particle Physics

Internship title: *A Light Higgs Boson in Light of Ultraviolet-Infrared Mixing*

Work description: See page 3

Application Procedures:

Prospective candidates should submit their application via email, including the following materials:

- A cover letter,

- A comprehensive academic curriculum vitae,

- All transcripts from the final year of their undergraduate degree (or equivalent).

Eligibility Requirements:

Applicants must have completed graduate-level coursework in quantum field theory and particle physics prior to the commencement of the internship.

Selection Process:

Shortlisted candidates will be invited to participate in an informal individual interview, conducted either via videoconference or in person, as part of the final selection process.

A Light Higgs Boson in Light of UV/IR Mixing

Florian NORTIER

September 2026

Electroweak symmetry breaking and the Higgs boson play a central role in Europe's experimental particle physics program, particularly at CERN's Large Hadron Collider (LHC) in Geneva [1]. Within the Standard Model, the Higgs boson is the only elementary scalar boson. However, its lightness—which lacks any symmetry protection—appears unnatural in the context of effective field theories [2]. This peculiarity suggests an underlying fundamental mechanism remains to be elucidated.

Historically, proposed solutions such as supersymmetry, composite Higgs models, and extra dimensions predicted new particles accessible at the LHC [2]. Yet, no experimental observation has confirmed their existence to date. Resolving this paradox has become a major challenge in theoretical particle physics, prompting the exploration of innovative approaches with novel experimental signatures [2].

Among these new approaches, ultraviolet-infrared mixing via classicalization [3] stands out for proposing new physics at energy scales necessarily higher than those envisioned by traditional models [4]. In this framework, new Higgs interactions dominate at multi-TeV scales, producing extended, massive objects—classicalons—governed by classical nonlinearities. These classicalons decay into a large number of particles, producing events known as fireballs [5]. This concept parallels black hole formation in ultra-Planckian gravitational collisions [6], where the Higgs boson rather than the graviton mediates the interaction. Furthermore, Higgs classicalization draws on mechanisms originally developed in dark energy theories, where a scalar field mediates a new gravitational interaction [7]. This paradigm thus establishes a conceptual bridge between electroweak physics and gravity, opening novel avenues toward a unified theory of fundamental interactions.

The research program at IP2I Lyon aims to explore the theoretical consistency of classicalization in the electroweak sector and its phenomenological implications for the LHC and future colliders. The selected student will join the research team working on this program. Depending on the project's progress and the student's interests, the work may focus on:

- a formal study (model building, analysis of model properties),
- a phenomenological approach (calculation of observables for direct and indirect new-physics searches at colliders).

This immersion will provide an introduction to the research topic and pave the way toward a PhD thesis or a "Projet Long de Recherche" for an ENS student.

References

[1] *The European Strategy for Particle Physics: 2026 Update - Recommendations by the European Strategy Group*, (Geneva), 2025, DOI.

[2] M. McCullough, *In Pursuit of New Paradigms: TASI 2024*, 2412.15744.

[3] G. Dvali, G. F. Giudice, C. Gomez and A. Kehagias, *UV-completion by classicalization*, *JHEP* **08** (2011) 108, [1010.1415].

[4] F. Nortier, *Light scalars in light of UV/IR mixing: classicalization via synergy between Vainshtein and chameleon screenings*, *JHEP* **03** (2026) 230, [2511.01739].

[5] C. Grojean and R. S. Gupta, *Theory and LHC phenomenology of classicalon decays*, *JHEP* **05** (2012) 114, [1110.5317].

[6] G. Dvali, C. Gomez and A. Kehagias, *Classicalization of gravitons and Goldstones*, *JHEP* **11** (2011) 070, [1103.5963].

[7] A. Joyce, B. Jain, J. Khoury and M. Trodden, *Beyond the cosmological standard model*, *Phys. Rept.* **568** (2015) 1–98, [1407.0059].