Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

Laboratory name: Laboratoire de Physique Théorique et Modélisation (LPTM)
CNRS identification code: UMR 8089
Internship director: Félix Rose / Nicolas Dupuis
e-mail: felix.rose@cyu.fr / nicolas.dupuis@sorbonne-universite.fr
Web page: https://felix-rose.github.io / https://www.lptmc.jussieu.fr/users/dupuis
Internship location: LPTM, CY Cergy Paris Université – Campus St Martin
(with discussions at LPTMC, Sorbonne Université)

Thesis possibility after internship: To be discussed.
Funding: internship: **YES**; thesis: NO If YES, which type of funding: Idex Paris Seine

High-order operator product expansion coefficients from the nonperturbative functional renormalization group

In the late 1960s, Wilson and Kadanoff suggested independently that in a quantum field theory the product of two operators in the short distance limit is equivalent to an infinite sum of operators multiplied by functions when inserted in any correlation function.

This so-called operator product expansion (OPE) is of fundamental importance in the study of conformal field theories (CFTs) in two and higher dimensions. Due to the strong constraint imposed on the correlation functions by the conformal symmetry, the OPE of two operators is uniquely determined by a set of numbers, the OPE coefficients. Along with the knowledge of the operators' scaling dimensions and spins, the OPE coefficients entirely determine the CFT, a huge simplification compared to general quantum field theories [1].

Unfortunately, the computation of these coefficients is difficult. The advent of conformal bootstrap (CB) [2] in the 2010s and recent proposals based on the fuzzy sphere regularization (FSR) [3] enabled the determination of many OPE coefficients in the universality classes of the Ising and O(N) models in dimensions $2 \leq d \leq 4$. In particular, FSR has predicted the value of high-order coefficients never computed otherwise.

Another method is the nonperturbative functional renormalization group (FRG), a versatile tool that has been used to study a variety of strongly correlated systems from high-energy physics to condensed matter theory [4]. The FRG has been used to recently extract from the momentum dependence of the correlation functions the leading order OPE coefficients in these models [5].

The goal of the internship is to extend these results and determine high-order OPE coefficients via the FRG. First, the intern will get familiar with the FRG and its momentum-dependence preserving approximation schemes. During the second part of the internship, they will generalize the method developed in Ref. [5] to determine higher-order OPE coefficients from the study of the RG fixed point equations.

[1] Di Francesco, Mathieu, and Sénéchal, *Conformal Field Theory* (Springer New York, 1997).
[2] Poland and Simmons-Duffin, *Nature Phys.* **12**, 535–539 (2016); Poland, Rychkov, and Vichi, *Rev. Mod. Phys.* **91**, 015002 (2019).
[3] Zhu, Han, Huffman, Hofmann, and He. *Phys. Rev. X* **13**, 021009 (2023); Hu, He, and Zhu, *Phys. Rev. Lett.* **131**, 031601 (2023).
[4] Dupuis, Canet, Eichhorn, Metzner, Pawlowski, Tissier, and Wschebor, *Phys. Rep.* **910**, 1 (2021).
[5] Rose, Pagani, and Dupuis, *Phys. Rev. D* **105**, 065020 (2022).

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: **YES** Soft Matter and Biological Physics: NO
Quantum Physics: **YES** Theoretical Physics: **YES**