

INTERNSHIP PROPOSAL

(One page maximum)

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Thesis possibility after internship: YES
Funding: YES

From $d = 4$ to $d = \infty$ and back: taming strongly coupled quantum field theory with a $1/d$ expansion

Summary

Quantum field theory is a century old, yet beyond weak coupling we still cannot compute how particles interact, that is, the S-matrix. Low-energy QCD is the classic example: we scatter hadrons in experiments, but cannot derive their collisions from first principles. This internship explores a fresh idea: use the number of spacetime dimensions, d , as a small parameter. The $1/d$ expansion has reshaped other fields, making mean-field theory exact in statistical physics and opening new analytic windows on black holes in general relativity. For scattering in quantum field theory, it is still waiting to be built, and it could reveal universal features of strongly coupled interactions.

The project grows out of our recent map, obtained with the S-matrix bootstrap, of which interactions are allowed in every dimension from 3 to 12, using only the consistency of relativity and quantum mechanics. We found surprising new phases appearing at special dimensions (5 and 7). These results touch a deep puzzle: beyond six dimensions, no fully consistent interacting theory without gravity is known, and string theory may be the only consistent option (string universality). Yet our bounds seem to allow interactions without gravitons. Is a graviton hiding somewhere in these amplitudes?

The work can be analytic, numerical, or both, depending on your interests. On the analytic side, you will study how the consistency conditions on the S-matrix simplify when d is large, and take first steps towards a $1/d$ expansion. On the numerical side, you will use our code to push the computations to higher dimensions and test the large- d predictions. The internship naturally opens to a PhD on quantum field theory, quantum gravity and string theory in higher dimensions, where the bootstrap, which assumes nothing about string theory, can test string universality directly.

You will join a small, friendly team of postdocs and PhD students, with regular one-to-one supervision and weekly group meetings where questions of any level are welcome. LAPTh is located in Annecy, between the lake and the mountains, close to CERN, and student housing is usually available through the university.

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

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