# Research internship on
# Stationary fluctuations in integrable spin chains and KPZ universality with boundaries

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*The internship may be followed by a PhD thesis.*

KPZ universality, from Kardar, Parisi and Zhang, describes the dynamics of large scale fluctuations in a variety of settings, such as growing interfaces, one-dimensional classical and quantum fluids, or random geometry, which exhibit characteristic long range correlations generated by local interactions. In the past decade, it has become a prominent topic at the interface between non-equilibrium statistical physics and probability theory, with recent experimental observations in a few classical and quantum systems [1].

KPZ fluctuations have in particular been observed in integrable spin chains [2], classical and quantum, in the early time regime where the correlation length is small compared to the system size. A goal of the proposed internship would be to explore the longer time scale associated with the relaxation of fluctuations to a non-equilibrium stationary state, when correlations eventually span the whole system. There, KPZ fluctuations *in finite volume* [3], taking into account boundary effects responsible for the spin current flowing into the system, are expected [4].

During the internship, after familiarizing herself / himself with integrable spin chains and their relation with KPZ fluctuations, the student will explore a quantum spin chain with dissipative boundaries, and especially analytical representations for its stationary density matrix, from which stationary spin fluctuations may be extracted.

Numerical computations are expected, but the balance between exact calculations and numerics will depend on the inclination of the student.

## References

[1] K.A. Takeuchi et al 2011 *Sci. Rep.* 1:34.
A. Scheie et al 2021 *Nature Phys.* 17:726–730.
D. Wei et al 2022 *Science* 376:716–720.
N. Keenan et al 2023 *npj Quantum Inf.* 9:72.
E. Rosenberg et al 2024 *Science* 384:48–53.

[2] M. Ljubotina, M. Žnidarič, T. Prosen 2019 *Phys. Rev. Lett.* 122:210602.
K.A. Takeuchi et al 2025 *Phys. Rev. Lett.* 134:097104.

[3] S. Prolhac 2024 *SciPost Phys. Lect. Notes* 81.

[4] S. Prolhac 2025 arXiv:2509.05176.