

# Exact results in out-of-equilibrium strongly interacting quantum models: The use of integrability

Édouard Boulat\*

[edouard.boulat@univ-paris-diderot.fr](mailto:edouard.boulat@univ-paris-diderot.fr)

---

Transport in nanoscale quantum devices can be described in some situations by quantum impurity models in which the low energy regime is often a strong coupling (SC) regime, the archetypical example maybe being the Kondo model. We have recently developed a framework for integrable models[1], in which we can exactly tackle various out-of-equilibrium situations for quantum impurities in their SC regime, using their equilibrium integrability properties. It allows to compute directly the expansion of the universal scaling functions for physical quantities (like the electrical current), in principle to arbitrarily high order in the driving out-of-equilibrium, be it voltage, frequency,... In particular, we show how to apply this to the Kondo model: our approach successfully goes beyond known results for the electrical current and noise.

[1]: L. Freton and E. Boulat, PRL **112** (2014) 116802.

---

\*Laboratoire de Matériaux et Phénomènes Quantiques, Université Paris Diderot - Paris 7, Bât. Condorcet, Case courrier 7021, 75205 Paris, Cedex 13, FRANCE.