Major Scientific Achievements

- **Critical behaviour of quantum long range $O(N)$ ferromagnets.** [*Phys. Rev.* B, **96**, 104432 (2017)]

  In presence of long range interactions quantum to classical correspondence is spoiled and the universal behaviour at the quantum critical point of an $O(N)$ ferromagnet un dimension d is not equal to the one of its classical equivalent in dimension $d+1$. I devised a generalisation of my early PhD studies to address the quantum critical behaviour of long range ferromagnetic models, leading to the best estimates, up to our knowledge, for the critical exponents of these systems. These results are fundamental to the interpretation of quantum stripe melting in low dimensional films with competing interactions. I developed the idea and carried on the calculation and interpreted the results. A. Trombettoni and S. Ruffo guided me through the literature and provided further physical insight.

- **Non-universal behaviour of topological phase transitions.** [*Phys. Rev.* B, **96**, 174505 (2017)]

  Low dimensional systems are characterised by the occurrence of topological phase transitions. The comprehension of this phenomenon dates back to 1973 and it yielded to its authors the 2016 Nobel prize in physics. However there is up to date no theoretical tool, apart numerical simulations, which is able to produce reliable estimations for the critical properties of this transition, spanning across the various different systems. I devised an extension of traditional Renormalisation Group approaches, which is able to describe the critical behaviour of such models including their non-universal corrections. I proposed the problem and devised a scheme for its solution also pursuing the numerical calculation necessary to prove the reliability of the technique.

- **Universal dynamical scaling in fully connected models.** [Phys. Rev. Lett. **121**, 240403 (2018)]

  The problem of universal dynamical scaling for fully connected models at slow drives has been source of enormous interest among the cold atom community, since the introduction of cavity QED and cold ion platforms. Still no ultimate answer had emerged for this problem due to the difficulty for numerical technique to access the scaling region and to the failure of traditional Kibble-Zurek scaling. Prof. G. Morigi draw my attention to this problem providing me with insight on the literature of these systems. I recognised the analogy of this problem to the one of a single Boson mode and I was able to derive an analytical solution to the problem, also interpreting all the previous numerical evidences found in the literature.

- **Quantum Anomalies in two dimensional fermi gases.** [Science **365**, 268 (2019)]

  As a member of the ISOQUANT collaboration, it is part of my project to interact with experimental groups. The comparison between the real space imaging of a two dimensional cold atom cloud and the measurement of its momentum distribution was devised by myself, during a discussion with Dr. Tilman Enss, in order to identify the corrections generated by the breaking of scale invariance due to quantum fluctuations. The experimental group of Prof. S. Jochim performed the measurement, leading to the first evidence of the anomaly in the dynamical evolution of these systems.

- **Topological phase transitions in high order correlations.** [*Phys. Rev. Lett.*, **123**, 100601 (2019)]

  It is commonly believed that, given two identical critical systems, e.g. spin systems, the introduction of a local coupling between the microscopic components of the two different systems does not generate any additional critical point, but only shifts the critical coupling at which the two models undergo spontaneous symmetry breaking. While this is true for second order phase transitions, an additional transition is noticed when coupling two layers, which both possess a topological phase transition of infinite order. This additional phase transition does not appear in the two point correlations, but rather in four point correlations where two variables of each layer are involved. I devised a self-consistent approach to study this exotic critical behaviour producing numerical estimations, which are in qualitative agreement with exact Monte Carlo simulations.