# Harnessing spin-qubit decoherence to probe strongly-interacting quantum systems

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Using a mobile qubit as a probe to study the properties of a larger quantum system is a novel technique that leverages the quantum nature of the probe, the system under study, and the interaction between them [1,2,3]. This enables accurate characterization of system properties that are impossible or hard to access using classical measurement schemes. By treating the system as an environment and analysing qubit decay or decoherence, this indirect approach provides experimental advantages due to the high tunability and accessibility of the qubit. Extending this method to strongly correlated systems, which exhibit complex and challenging-to-measure properties, is particularly valuable. Here, we apply this method to investigate the anisotropic Heisenberg XXZ spin-1/2 chain, an archetypal strongly correlated system [4]. By integrating the Time-Convolutionless (TCL) projection operator method with the Time-Dependent Variational Principle (TDVP), we achieve a reliable evolution of the qubit and interpret its decoherence in terms of system characteristics. This combined approach facilitates the identification of critical quantum phase transitions, offering a powerful tool for probing intricate quantum systems.

## References

1. A. Relaño, J. M. Arias et al, Physical Review A 78, 060102 (R) (2008).
2. E. Vicari, Physical Review A 98, 052127 (2018).
3. B. Flebus, H. Ochoa et al, Physical Review B 98, 180409(R) (2018).
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## Figures

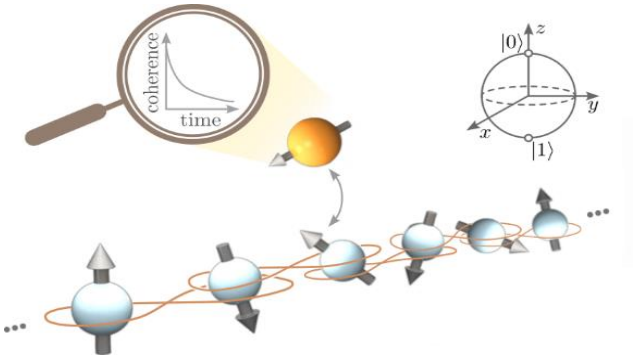


**Figure 1:** A spin-qubit probe is coupled to a strongly correlated quantum spin chain, where the chain serves as its environment, leading to decoherence of the qubit.

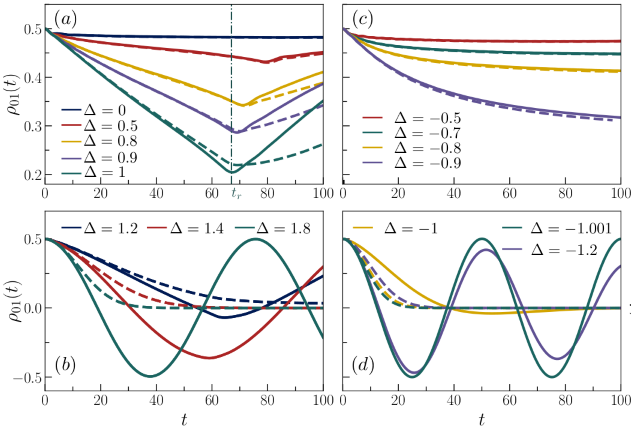


**Figure 2:** Evolution of qubit coherence for different values of the anisotropy parameter (Δ) of the spin chain.