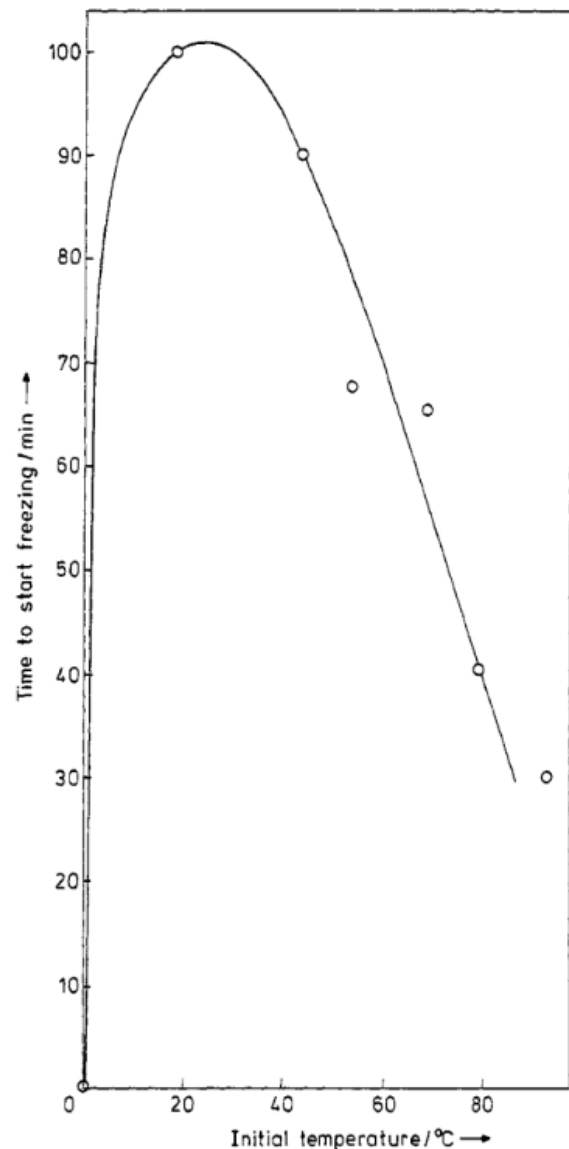


Quantum Mpemba effect: why hot water can make ice faster than cold water

It is generally expected that a hotter system will take longer to cool than a colder system. Nevertheless, this is not always true. Sometimes, a hotter system cools down faster than a cold system. This unusual phenomenon is known as the Mpemba effect, and it has been documented since the time of Aristotle, when people used hot water to melt ice more quickly than cold water. Moreover, the microscopic mechanisms underlying this unusual effect remain under debate. This project aims to study the Mpemba effect in quantum systems. Using a microscopic thermalization model, we will explore the conditions under which the Mpemba effect occurs and elucidate the underlying microscopic mechanism. During the project, the students will learn open quantum systems theory, the basic theoretical framework for describing thermalization processes, noise, and decoherence in quantum computers.

References:

- Mpemba, Erasto B., and Denis G. Osborne. "Cool?." *Physics Education* 4.3 (1969): 172-175.
- Lu, Z., & Raz, O. (2017). Nonequilibrium thermodynamics of the Markovian Mpemba effect and its inverse. *Proceedings of the National Academy of Sciences*, 114(20), 5083-5088
- Avitan, Ido, Roei Factor, and David Gelbwaser-Klimovsky. "Necessary conditions for the Markovian Mpemba effect." *arXiv:2603.04567* (2026).



Prerequisites: Basic programming skills in any language (python, mathematica, matlab, etc) and basic quantum mechanics