Time glasses, imaginary time crystals, and all that

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One of the foremost objectives of statistical mechanics is the description of the thermodynamic properties of quantum gases. Despite the great importance of this topic, such achievement is still lacking in the case of non-Hermitian quantum gases. Here, we investigate the properties of bosonic and fermionic non-Hermitian systems at finite temperatures. We show that these systems exhibit oscillations both in temperature and imaginary time. As such, they can be a possible platform to realize an imaginary time crystal (iTC) phase. The Hatano-Nelson model is identified as a simple lattice model to reveal this effect. Our realization of an iTC is effectively a way to filter one specific Matsubara mode. Hence, the Matsubara frequency, which usually appears as a mathematical tool to compute correlation functions at finite temperatures, can be measured experimentally [1].

In the second part of this talk, I will discuss a recent study of the fractional Langevin equation with white noise. By varying the value of the derivative in the friction term of the Langevin equation, we show that it is possible to connect different states of matter, namely a liquid, a glass, an anomalous glass, and even a time glass. The latter emerges in the subohmic regime of a system plus bath description and corresponds to a system with a fractal structure in the free energy landscape [2].

[1] *Non-Hermitian quantum gases: a platform for imaginary time crystals*, R. Arouca, E. C. Marino and C. Morais Smith, in print, Nature Quantum Frontiers, June 2022.

[2] *Time glass: a fractional calculus approach*, R. C. Verstraten, R. F. Ozela, and C. Morais Smith, Phys. Rev. B 103, L180301 (2021).