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"Quantum correlations: Where are they? How do they build up?
How to measure them?"

When a system is composed of many parts, "more is different" (as P. W. Anderson famously wrote) if and only if there are correlations among the various parts. If the constituents are quantum mechanical atoms, spins, oscillators, etc., "more" can be even "more different", as correlations can take forms which are impossible in classical mechanics. The most famous, yet elusive form of quantum correlation is represented by entanglement, a property well defined and investigated for pure states, and envisioned as a resource for nearly all technological tasks harnessing quantum many-body systems. In the real life of mixed states incoherent fluctuations appear in the game, making the distinction of quantum vs. classical correlations less sharp. At the same time, the exquisite level of control achieved by experiments in atomic, molecular and optical (AMO) physics enables nowadays to engineer correlated phases of quantum many-body systems, so that the ability to characterize and control quantum correlations becomes a fundamental question, as well as (possibly) a technological one.

In this colloquium I will try to offer a broad overview of the theoretical importance of quantum correlations, starting from their very definition - to which we contributed recently with a statistical physics approach which allows to calculate them in generic systems, and potentially to measure them for a large class of quantum many-body systems relevant to experiments in AMO physics and beyond. I will moreover discuss the centrality of quantum correlations in the dynamics that leads a closed quantum system to relax to an equilibrium state, contrasting the case of short-range interactions with that of long-range ones: this contrast allows to enlighten the role of elementary excitations (and in particular of their dispersion relation) as the "carriers" of quantum correlations.