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Have Ultracold Atoms Led to Progress in Theoretical Physics?

Ultracold atoms have opened new directions in physics, both by realizing paradigmatic models in many-body and statistical physics and by allowing to explore phenomena which have never been accessible before. In this talk, I will discuss to which extent ultracold atoms have also triggered new developments in theoretical physics.

It is shown that for the quantum many-body problem with zero range interactions which appears naturally in the context of ultracold atoms, there are a number of exact relations which connect the short distance behavior of the one- and two-body density matrix with thermodynamic properties and also the high-frequency or large momentum behavior of correlation functions. These relations follow from a Wilson operator product expansion and thus apply to arbitrary states of the many-body system. Two examples for their concrete application are given: the violation of scale invariance in RF-spectroscopy of two-dimensional Fermi gases and deep inelastic scattering on strongly interacting Bose gases at large momentum.