Quantum coherence of Hard-Core-Bosons and Fermions: Extended, Glassy and Mott Phases

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Disorder has drastic effects in quantum systems of fermions and bosons. For non-interacting particles it leads to Anderson localization and to a metal-insulator transition. When interactions are present, the effects are even more drastic and the different phases induced by the interplay between disorder and interactions has been a topic of continuous theoretical interest. Cold atoms confined by a periodic lattice offer a unique laboratory to explore disordered systems in a controlled manner. In this talk I will discuss the use of Hanbury-Brown-Twiss interferometry (HBTI) to study various quantum phases of hard core bosons (HCBs) and ideal fermions confined in a one-dimensional lattice plus an additional quasi-periodic (QP) potential introduced to add pseudo-random disorder. I will show that in the localized phase, except for the sign of the peaks, both HCBs and ideal fermions exhibit identical interferometric patterns. We find that HBTI provides an effective method to distinguish Mott and glassy phases. On the other hand I will discuss the different behavior exhibited by HCBs and fermions in the extended phase. We find that the QP potential induces for HCBs a cascade of Mott-like band-insulator phases, in addition to the Mott insulator, Bose glass, and superfluid phases. At critical filling factors, the appearance of these insulating phases is heralded by a peak to dip transition in the interferogram, which reflects the fermionic aspect of HCBs. On the other hand, we find ideal fermions in the extended phase display various features characteristic of incommensurate structures such as devil's staircases and Arnold tongues.