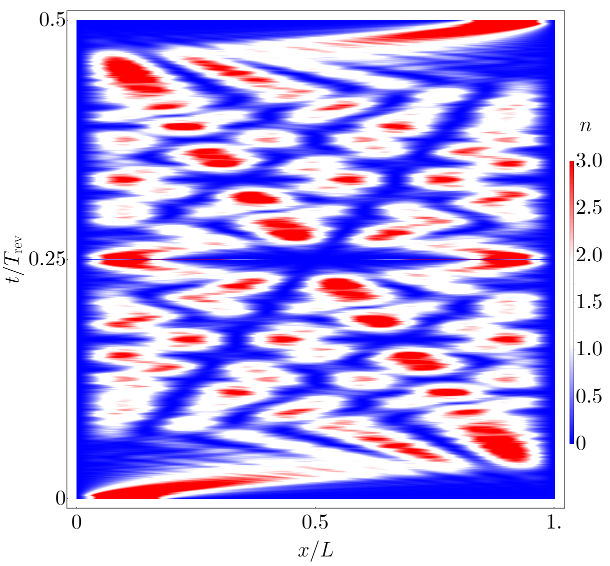
In 1836 Henry Fox Talbot, the father of photography, reported an unexpected result – a diffraction grating he was observing through a magnifying lens was reappearing repeatedly in focus as he was moving away. This effect, now dubbed the Talbot effect, is a consequence of a interference of highly coherent waves and it is not surprising that there exists its quantum counterpart. In general, relative phases of states in a quantum superposition evolve in time and for some systems it may happen that these phases cyclically repeat particular configurations, causing a revival of the initial state. Such a behavior inspired many ideas that go by different names, but share the same origin. From within these phenomena, we focus on aesthetically appealing *quantum carpets* – spatiotemporal representations of a probability density of a quantum particle in a box (see Fig. 1(a)).



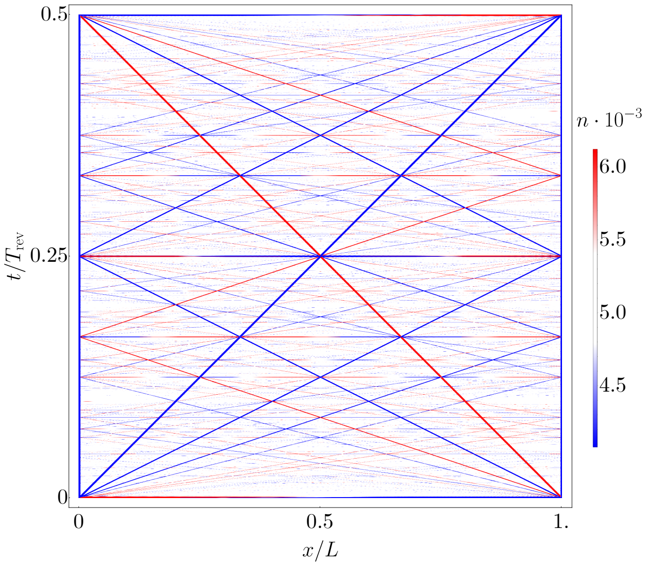


Figure 1: Radially-integrated probability density plots for one atom (left) and 5000 atoms (right) initially confined to a box with the width of $D/L = 0.21$ and a perpendicular harmonic trap. In contrast to usual one atom situation in which blurry canals and ridges emerge, scenario involving larger number of atoms is characterized by much sharper features. These structures become solitonlike – thin, localized, and shape-preserving.

Quantum carpets were discussed almost exclusively in bosonic systems – whether it was light or a Bose-Einstein condensate. However, in our recent work, we find that even in the limit of ideal gas of polarized fermions in an infinite well, some interesting phenomena arise. We show that degenerate Fermi gas that is initially trapped in a box and then released into a bigger one exhibits solitonlike structures (see Fig. 1(b)).

This newly explored phenomenon provides a playground for a novel theoretical research and we want to capitalize on that. Two routes seem appropriate and natural for a further investigation.

Correlations in fermionic quantum carpets of two-component repulsive gas

In our previous work, we did not accommodate for quantum correlations in the system. However, in a strongly interacting regime, they undoubtedly play a significant role, supposedly changing the character and behavior of coherent, solitonlike landscape we can observe in a weakly interacting gas. We plan to investigate our system with more realistic Ansätze for the wave functions, that inherently contain non-trivial quantum correlations and interspecies entanglement.

Quantum carpets as a searching tool for exotic quantum states

Quantum carpets appear in plethora of different systems, many of which was not studied from this perspective. Emergence of such structures usually signifies a complicated evolution that can engineer exotic quantum states. We aim to use the quantum carpet pattern to search for such states, as fractional revivals of the initial configuration can suggest a highly entangled state present in the system. Our particular interest would be focused on the so-called coherent phase state that undergoes an evolution generated by Bose-Hubbard Hamiltonian without tunneling.

Each of the proposed tasks introduces a new quality by either connecting problems from different branches of physics or investigating a novel tool that a broad audience of quantum information society might find useful. Taking correlations into account in the dynamical system of repulsive two-component Fermi gas would not only study behavior of intriguing patterns known as quantum carpets, but would also shed light on the long standing problem of the ferromagnetic instability in such a binary spin-mixture. Moreover, quantum carpets on their own offer a visual probe to scan for exotic quantum states in various physical setups. We propose to investigate this feature in order to test its effectiveness by studying a system widely used in the quantum information science.