Interaction of particles leads to exchange of energy among them and typically, for open systems to their thermalization. The same phenomenon occurs for closed systems, where a local small part typically thermalizes due to contact with the rest (although the full system evolves unitarily) – at least this is what the so called eigenstate thermalization (ETH) hypothesis established in last millennium says. Last fifteen years brought intensive studies of cases, when this picture does not work. It was shown, almost proved, that in strongly disordered systems we observe many-body localization, the nonergodic behaviour that leads to a strong memory of the initial state and weak exchange of the information between the time-evolved state and the rest of the system.

In last five years it became more and more apparent that nonergodic dynamics may occur also in the absence of the disorder, even more surprisingly violating ETH. Several systems were shown to exhibit such a behavior. It was shown, for example, that the global tilt of one-dimensional system, analogous to the potential of a charged particle in electric field, leads to such a nonergodic dynamics. This has been associated with the so called shattering of the Hilbert space and the existence of emerging almost conserved constants of motions (such as a global dipole moment). Similarly low dimensional lattice gauge theory models show nonergodic motion that may be traced back to the existence of a generalized Gauss law. It has been suggested that strong, long range interactions or the so called frustration lead also to the nonergodic behaviour.

This project aims at understanding of the occurrence of the non-ergodic dynamics in strongly interacting many-body systems. What are the necessary ingredients for the system to behave in a nonergodic way? Are approximate constant of motions necessary? What is the relation to the structure of the Hilbert space? What is the behaviour of the observables, in particular of the associated, the so called, spectral functions that reflect the frequency response of the observables? The aim is to understand the limits of generality, the necessary ingredients, identifying characteristic features of models leading to such a nonergodic behavior.

The project is planned in a close collaboration between Slovenian and Polish teams. Both of them study various aspects of interacting many-body systems for a number of years, working recently both on MBL as well as on disorderless systems such as fermions (spins) in tilted lattices, examples of constrained dynamics in lattice gauge theories, systems with global conservation laws etc. The teams bring diverse experience and tools developed by both sides ranging from analytical calculations (renormalization group, finite size scalings), different techniques for time-dynamics studies using tensor networks (TDVP, TEBD codes) or exact diagonalizations. While up till now only autonomous disorder-free systems revealed nonergodic dynamics we want to identify periodically driven systems with similar characteristics. In particular whether and how Hilbert space shattering may affect eigenphases of Floquet dynamics operators? We want also to study systematically the effect of weak interactions on many-body integrable models.