Periodically driven systems can display new many-body phases. One kind of such phases are time crystals – quantum many-body systems that, due to interactions between particles, are able to spontaneously self-organise their motion in a periodic way in time by analogy with the formation of crystalline structures in space in condensed matter physics.

In solid-state physics properties of space crystals are often investigated with the help of external potentials that are spatially periodic and reflect various crystalline structures. A similar approach can be applied for time crystals, as periodically driven systems constitute counterparts of spatially periodic systems, but in the time domain.

Employing periodically driven systems we propose quantum simulators, which promise access to programmable exotic long-range interactions in solid-state-like many-body problems, systems with topological protection of time correlations, methods to investigate Anderson localisation physics in the time domain and quasi-crystalline structures in time. These propositions can be realised experimentally, for example, in ultra-cold atoms bouncing resonantly on an oscillating atom mirror.