Time Crystals

We all know crystals but time crystals sound quite strange. Space crystal, that is a normal crystal, corresponds to a regular arrangement of atoms in space. Quantum mechanics tells us that in order to observe a crystalline structure in space, spontaneous breaking of space translation symmetry is required. In other words position of a single atom has to be measured before probabilities of measurements of next atoms reveal periodic behaviour in space.

Spontaneous formation of crystalline structures in time is termed time crystals. Time crystal is related to periodic motion of a system but not every periodic motion is identified with the formation of a crystalline structure in time. Periodic motion of hands in a clock is not spontaneous because they are driven by an internal "engine." Time crystal idea is related to a situation where a system is prepared in the lowest energy state and any, even infinitely weak, perturbation uncovers periodic motion of a system. Such phenomenon was proposed by Noble prize winner Frank Wilczek and T. Li and co-workers two years ago and initiated a debate in the scientific literature whether it is realistic. The purpose of the project is to perform many-body quantum simulations of the time crystal formation and to dispel doubts present in the literature.

The idea of Wilczek and Li and co-workers constitutes an inspiration for us. It turns out that interesting crystalline phenomena in the time domain can be realized also in periodically driven systems. Time periodic perturbation is an analogue of space periodic potentials in models of condensed matter physics. It opens a possibility for investigation of a wide range of solid state phenomena in the time domain what is also the objective of the project.

Possibility of practical applications of time crystals is unclear at this moment. We can anticipate that they can be used to build frequency standards which base on macroscopic phenomena or they can be used in precise measurements of magnetic fields by comparing periods of their motions with accurate time of atomic clocks.