Realization of Time Crystals in ultra-cold atomic gases

Time crystals sound more like science fiction than a serious scientific concept. In 2012 theoretical physicist and Nobel laureate, Frank Wilczek, asked the question if quantum many-body systems can form spontaneously crystalline structures in time. In other words if a many-body system, due to interactions between particles, is able to switch spontaneously to a periodic motion. The initial Wilczek idea turned out to be impossible to realize but the novel research area has been established and it is developing quite rapidly. It has been already demonstrated in the laboratory that quantum many-body systems which are periodically driven can crystalize in time with a period which is different from the period of the time-dependent driving. Moreover, it has been predicted that a whole bunch of condensed matter phenomena can be realized in the time domain.

Objectives of the Project

In the group of Prof. Peter Hannaford in Swinburne University of Technology in Melbourne there will be performed experiments on time crystals in ultra-cold atoms bouncing on an oscillating atom mirror. We will constitute the theoretical force of the experiments. The Project is also devoted to theoretical research of crystalline structures in time.

Description of the research

A whole bunch of condensed matter phenomena in time crystals we have proposed recently will be realized in the laboratory in Melbourne. That is, Anderson and many-body localization in the time domain, time quasi-crystals, topological time crystals, many-body systems with exotic long-range interaction and dynamical quantum phase transition in time crystals can be experimentally investigated in ultra-cold atoms bouncing on an oscillating atom mirror. We will also perform theoretical research of new kinds of crystalline structures in time.

Justification of the Project

Time is becoming our new ally — an additional degree of freedom whose exploration opens possibilities for novel time devices or spatio-temporal equipment. We believe that the research on time crystals has so far revealed only the tip of the iceberg — the most exciting part is yet to come. Our collaboration with Peter Hannaford will demonstrate that condensed matter physics in the time domain is attainable experimentally. It will be the first stage in combining a crystalline structure in time with crystalline structures in space. Such space-time crystals could offer novel possibilities which can lead to building new spatio-temporal electronics.