In 2011 Dan Shechtman was awarded with a Nobel Prize in the field of chemistry for the discovery of a new form of organization of the atomic structure of solids, i.e., quasicrystals. In nature, such type of atomic order was only identified in the minerals of certain meteorites, like in the icosahedrite ($Al_{63}Cu_{24}Fe_{13}$) phase of Khatyrka carbonaceous chondrite. Contrary to the commonly occurring crystalline substances, in the case of quasicrystals, arrangement of the ordered atoms is not periodically repeating itself in space. This entails the unique physical properties of such materials, related to the electronic transport, magnetic properties and plastic deformation mechanism.

Majority of the known quasicrystals do not exhibit near-room temperature long-range magnetic order, which is demanded for their possible applications, eg. to develop the memory based on ferrimagnet with ultrafast magnetization reversal. Such materials are sought, because a range of interesting phenomena might be associated with their aperiodic structure, such as so-called itinerant electron system or localization of the magnetic moments on the orbitals of only part of the atoms that bear *d*-electron subshell.

In the current study, for the initial alloy composition I have chosen thermodynamically stable quasicrystalline phase in Al-Cu-Fe(B) system, which will be modified by the addition of metals from lanthanide group. Novel compositions that contain quasicrystalline phases and exhibit long-range magnetic order at near-room temperature will be selected. The samples will be investigated in the search for the occurrence of ferrimagnetism, quantum criticality, intermediate-valence state and spin glass with non-equilibrium spin dynamics leading to memory effects.

First, free solidification on water-chilled copper block will be employed to obtain multi-phase aluminum-based alloys. Improvement of thermal stability of the quasicrystalline phase will be conducted by doping and assessed by calorimetric methods. Structure of the samples will be determined with X-ray diffractometry, scanning and/or high-resolution transmission electron microscopy. Compositional analyses will be conducted with energy-dispersive X-ray and X-ray photoelectron spectroscopy methods. Magnetic measurements will be performed by means of alternating and direct current SQuID magnetometry. Specific heat measurements in cryogenic temperatures will be realized by thermal relaxation method. Properties of the materials would be also modified by heat treatment if necessary.

The study will explore new route for synthesis of quasicrystalline magnetic materials, i.e., the shock wave after treatment of multi- and single-phase samples, utilizing the methodology developed by the project partners from California Institute of Technology. Selected magnetic multi-phase alloys with quasicrystalline phases subjected to the short pulse of extreme pressure are expected to contain phases with novel, meta-stable compositions, structural defects or internal strain that will alter their magnetic properties.

Microstructure of alloys produced that way will contain a mixture of phases with known structure and composition. In this step, I will know, that combination of certain composition and manufacturing procedures will lead to desired magnetic properties of the sample as a whole. The fundamental question here will be, which phase(s) of the alloy are responsible for its bulk magnetic behavior? To properly address it, two independent procedures will be performed.

Polished, flat cross-sections of multi-phase alloys will be investigated by means of scanning SQuID microscope, which is able to map the vertical component of the magnetic field with the sensitivity as high as 10-16 Am^2 and a maximum spatial resolution of 10–20 μm, including mapping of remanent magnetic moments. This information, compared with electron microscopy and X-ray diffractometry data will allow to ascribe the observed macroscale magnetic properties to the certain phase. The task will be performed using California Institute of Technology infrastructure.

The second step is to produce single crystals of magnetic quasicrystalline phases identified in the multi-phase magnetic alloys. Single crystal growth will be realized by means of self-flux method at the University of Wrocław. Finally, as-prepared and shockwave treated single crystals will be compared in the terms of composition, structure, thermal stability and fundamental magnetic properties.

It is highly probable that the results of experimental works conducted within this project will stimulate the extended theoretical investigation by other researchers in the field.