Present Research at Toyota Riken
Quasicrystals and related crystals

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Purpose of research

A quasicrystal exhibits "a specific diffraction symmetry" and "a long-range order (quasiperiodicity)" that is regular but not periodic. The purpose of this research is to clarify how such a unique structure is formed as an array of atoms and further what kind of physical properties the order brings. I would like to conduct research by searching for new substances while comparing with conventionally known quasicrystals and approximant crystals. The final goal is to review metallic solids from the viewpoint of quasicrystals and lead to "a new solid view".
(See Research Overview for detail.)

Research plan

I am considering experimental research with emphasis on original sample development. There are two major directions set in the research strategies.

(1) Adventures searching for new type of quasicrystals

The dodecagonal quasicrystal was reported for the first time by the authors in 1985, but the homogeneity and structural integrity are still low comparing with traditional icosahedral quasicrystals such as Al-Cu-Fe. For this reason, no sample is available for physical property study. In my research plan, two types of crystal structures, hexagonal ZrNiAl-type and tetragonal Mo_2FeB_2-type, are assumed as starting materials, both of which can be regarded as approximants of a dodecagonal quasicrystal*. It is aimed to establish new type of dodecagonal quasicrystal.

Another subject in this category is to search for new valence-fluctuating quasicrystal following Au-Al-Yb. Approximant crystals containing rare-earth elements such as Yb have been selected as starting materials. In the last decade, constituent substitution was intensively carried out using the Au-Al-Yb icosahedral quasicrystal as a starting material. However, in many cases only approximant crystals were found. Then it is time to change tactics.

*T. Ishimasa, M.Mihalkovič, K. Deguchi, N.K. Sato, M. de Boissieu, Interpretation of some Yb-based valence-fluctuating crystals as approximants to a dodecagonal quasicrystal, Phil. Mag., **98** (2018) 2018.

(2) Continuous research subjects: Real structure of icosahedral clusters

Tsai-type cluster included icosahedral quasicrystals and their approximant is studied here. In these structures, an atomic group, cluster, having a diameter of approximately 14 Å is a common structural unit. The cluster is composed of triple concentric shells with icosahedral symmetry, and it is thought that four atoms are contained in the center of the cluster. There is a symmetry mismatch

inside the shell and the internally. This mismatch causes interesting phenomena called "dynamical flexibility" in the case of Zn-Sc system. In this research it is aimed to understand deeply the real structure of the icosahedral clusters.