Valence instability and quantum criticality in Yb-based quasicrystals and approximant crystals.

K. Imura[1], S. Yokota[1], K. Sakamoto[1], K. Namba[1], S. Hirokawa[1], K. Deguchi[1], H. Yamaoka[2], Y. Yamamoto[3], T. Kawai[3], J. Mizuki[3], N. Hiraoka[4], H. Ishii[4], T. Ishimasa[5] and N. K. Sato[1]

[1] *Department of Physics, Graduate School of Science, Nagoya University, Nagoya 464-8602, Japan*

[2] *RIKEN SPring-8 Center, Sayo, Hyogo 679-5148, Japan*

[3] *Graduate School of Science and Technology, Kwansei Gakuin University, Sanda 669-1337, Japan*

[4] *National Synchrotron Radiation Research Center, Hsinchu 30076, Taiwan*

[5] *Toyota Physical and Chemical Research Institute, Aichi 480-1192, Japan*

Au–Al–Yb quasicrystal (QC) and approximant crystal (AC) possess Tsai-type cluster structure [1]. Yb ions locating 12 vertexes of an icosahedron are intermediate-valence state between Yb^{2+} and Yb^{3+} [2]. Recent discoverys of unconventional quantum criticality in Au–Al–Yb QC, and Au–Al–Yb AC under pressure attract much attentions [3, 4]. In the critical region, the uniform magnetic suceptibility diverge as $1/\chi \sim T^{0.51}$ toward zero temperature. Though the importance of the effect of quasiperiodicity or/and valence fluctution has been discussed, the origin of the quantum criticality is still under debate.

We have performed direct observation of Yb mean-valence of several polycrystalline Yb-based QCs and ACs, by means of Yb-L_3 edge x-ray absroption spectroscopy in high-resolution partial fluorescence yield mode (PFY-XAS). All experiments were carried out at the inelastic x-ray beamline BL12XU at SPring-8. We found that ternary Au–Ga–Yb QCs/ACs, and quaternary (Au,Cu)–Al–Yb and Au–(Al,Ga)–Yb QCs are new family of intermediate-valence systems. We also found that the Yb mean-valence shows a peculiar evolution as a function of 6- or 3-dimensional lattice constants suggesting valence crossover or transition at the critical lattice constant.

In this presentation, we will show the detailed experimental setup and results including uniform magnetic susceptibility measurements, and discuss a relationship between the valence instability and quantum criticality of Yb-based QCs/ACs. We will also show the new experimental results of Zn–Au–Yb QC/AC that are most recently synthesized by Ishimasa.

* e-mail: imura.keiichiro@a.mbox.nagoya-u.ac.jp.

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