Shedding Light on the Mysterious Ordering Pattern

A joint study lifted the curtain on the mysterious "hidden order" of a uranium compound in condensed matter physics. That is, the mechanism of a phase transition in URu_2Si_2 was clarified by Profs. Hiroaki Ikeda, Takasada Shibauchi and Yuji Matsuda at Kyoto University, Prof. Ryotaro Arita at the University of Tokyo, Dr. Michito Suzuki at Japan Atomic Energy Agency and Dr. Tetsuya Takimoto at the Asia Pacific Center for Theoretical Physics (APCTP).

It is well known that URu_2Si_2 shows an unknown phase transition at 17K, below which superconductivity appears at 1K. For this mysterious ordering pattern, physicists could detect only the transition, but what happens actually in the phase has been veiled for 25 years in spite of intensive experimental and theoretical investigations. Therefore, it is called "a hidden ordered state" in the research field.

In order to unveil the mystery, researchers have introduced 36 multipoles (generalized moments up to the rank 5) from a 5f-electron of the uranium ion in URu_2Si. Reflecting the detail electronic states above the transition temperature, they have extracted an ordered state of a rank-5 momentum, which provides a reasonable solution for the hidden order.

Not only has the research solved this long-standing problem, but the research results also have revealed that URu_2Si_2 has a novel quantum state with a high rank moment. In addition, the approach developed through this research provides indispensable information for material science by providing a new theoretical method to search an electronic state.

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Dr. Tetsuya Takimoto, one of the coauthors, has been currently conducting research in the Junior Research Groups (JRGs) at the APCTP. With a view to offering next generation scientists opportunities to build research capacity, the JRGs were formed under the Memorandum of Understanding with the Max Planck Society. Since opening in October 2007, the JRGs have achieved excellence in the fundamental sciences.

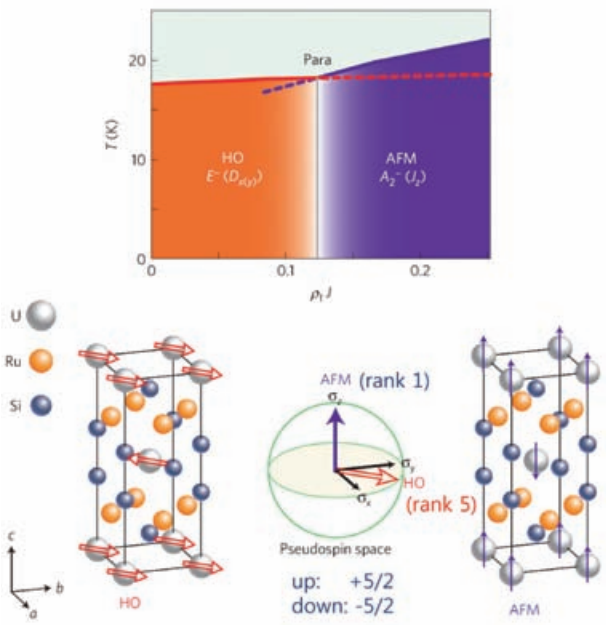

Fig. 1: (upper panel) Calculated temperature-coupling constant (corresponding to pressure roughly) phase diagram. In the small J region, the ordered state of rank-5 moments are stabilized to describe the hidden order.
(lower panel) Multipole structures of HO (hidden order) and AFM (antiferromagnetic) states. The HO (AFM) state shows an ordering of pseudospins parallel (perpendicular) to ab-plane, where the pseudospin is formed by +5/2 and -5/2 states of j=5/2 multiplet of 5f-electron.