The 21 Century COE Project

Exploring New Science by Bridging Particle-Matter Hierarchy

Short-term Foreign Researchers

Research Report

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Your Stay Period in Japan: From 2004 January 14 to 2004 January 16

Title of Research in Japan: NMR Studies of Actinide Compounds

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Please write a research report of one or more pages and submit it with this cover to your host researcher till the end of this March.

Actinide oxides and intermetallic compounds present a number of interesting and unsolved problems in the field of condensed matter physics. At the Advanced Science Research Center of the Japan Atomic Energy Research Institute at Tokai, the Uranium NMR Group has undertaken a program of NMR studies aimed at unraveling the mysteries of these fascinating materials. Inspired by the original observation of solid-state ^{235}U NMR made by Ikushima and Yasuoka, we envision the study not only of ligand NMR in these systems, but also of the actinide nuclei themselves (e.g., ^{235}U and ^{237}Np), which probe directly the behavior of the 5*f* electrons. During my visit to Sendai, I gave a seminar titled "NMR Studies of Actinide Compounds", in which I presented and discussed results from our recent studies of ^{235}U and ligand NMR in UGa_3, USb_2, URh_3 and NpO_2. The first two of these are metallic antiferromagnets, though with rather different properties. UGa_3 shows orbital ordering and has an unusual "double" second-order phase transition. USb_2 is a more conventional antiferromagnet, but represents, we believe, the first observation of ^{235}U AFNMR in a metallic system. URh_3 is a conventional Pauli paramagnet, in which we used ^{103}Rh NMR measurements to indirectly measure the spin-lattice relaxation time T_1 of the ^{235}U nuclear spins, the first such measurement in a metallic host. Finally, NpO_2 is an insulating compound with a highly unusual quadrupolar-octupolar ground state. Our ^{17}O NMR study of the ordered state is the first such study of a neptunium compound, with interesting implications for the nature of the ordered state. Besides the seminar, I made intensive discussions with Prof. S. Takagi and his graduate students on their recent NMR/NQR studies of UGa_3, URu_2Si_2, Yb_4As_3 and related systems. Particularly I spent lots of time on UGa_3 for discussing their new NMR data in the ordered state and their quite different interpretation of the data from ours without invoking orbital ordering. In addition I made extensive discussions on ^{29}Si NMR/^{101}Ru NQR studies on hidden order in a heavy-electron superconductor URu_2Si_2 and also on ^{171}Yb NMR studies on charge ordering in a quantum-spin-chain system Yb_4As_3, which, I believe, had many implications for our recent work. Intensive discussions on theoretical aspects of the NpO_2 problem with Prof. Y. Kuramoto and Dr. K. Kubo were also very helpful in advancing our analyses in a more quantitative way. Although it was a three-day short visit, it was really very fruitful and I gratefully appreciate this opportunity.