$Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$の特異なスピン液体状態

Novel quantum spin liquid state in $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$

安井 幸夫[1] 寺崎 一郎[2] Puspita Sari Dita[3] 渡邊 功雄[4] 井川 直樹[5]

Yukio YASUI Ichiro TERASAKI Puspita Sari Dita Isao WATANABE Naoki IGAWA

[1]明治大学 [2]名古屋大学 [3]芝浦工業大学 [4]理研 [5]原子力機構

（概要）

We have discovered a novel type of quantum spin liquid in $Ba_3ZnRu_2O_9$, which has a hexagonal lattice of Ru^{5+} dimers. We have also studied the magnetic behavior of the Nb-doped system $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$, where the Nb^{5+} $(4d)^0$ is non-magnetic ion and disturbs the formation of the Ru^{5+} dimer. By the Nb-doping, a ferromagnetic transition appears at around 100 K for $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$ ($0.08 < y$). In order to study the magnetism of quantum spin liquid and/or ferromagnetic states at low temperature, we performed neutron powder diffraction of three samples $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$ (y = 0, 0.06, and 0.12). I found the three magnetic Bragg peaks with tiny diffraction intensity. From the results of neutron diffraction measurements, we consider a novel scenario in this system wherein a spin liquid state accommodates long-range magnetic ordering with a tiny ordered moment.

キーワード：スピン液体、Ru ダイマー、特異な磁気状態、長距離磁気秩序

（1 行あける）

１．目的

We discovered a novel type of quantum spin liquid in $Ba_3ZnRu_2O_9$, which has a hexagonal lattice of Ru^{5+} dimers.[1,2] In the temperature (T) dependence of the magnetic susceptibility (χ) of $Ba_3ZnRu_2O_9$, no trace of the Curie tail or glassy behavior has been detected down to 50 mK. We studied the magnetic behavior of the Nb-doped system, $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$, where Nb^{5+} $(4d)^0$ is a non-magnetic ion that disturbs the formation of the Ru^{5+} dimer. The $\chi - T$ curves of the Nb-doped system also show no trace of the Curie tail at low temperatures, indicating that the local Ru^{5+} spin induced by Nb-doping does not act like a free spin. The spin liquid state of $Ba_3ZnRu_2O_9$ has been found to be robust by impurity doping.

To study magnetic dynamics at low temperatures, we attempted to perform neutron powder diffraction of three samples $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$ (y = 0, 0.06, and 0.12) down to 10 K.

２．方法

We measured the powder neutron diffraction profiles of three samples $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$ (y = 0, 0.06, and 0.12) using HRPD in JRR-3. Measurement temperatures are at 10 K, 20K and 130K

３．結果及び考察

Figure 1 shows examples of neutron diffraction profiles of $Ba_3ZnRu_2O_9$ taken at 10 K and 130K. We can see the growth of intensities of the magnetic reflections 113, 202, and 204, which are indicated by arrows. Blue line of Fig. 1 indicates the intensity difference between the data at 10 K and at 130K, indicating that the magnetic ground state of the spin system is magnetic long-range ordered state. Because we can detect three magnetic Bragg peaks only, it is not easy to determine the magnetic structure of this system. We are analyzing the magnetic structure comparing that of the similar material $Ba_3MRu_2O_9$ (M=Co, Ni, and Cu). From the preliminary analysis, we found that the ordered moment of the Ru^{5+} spin of $Ba_3ZnRu_2O_9$ is much smaller than 3 μ_B derived from spin S=3/2. Then, we consider a novel scenario in this system wherein a spin liquid state accommodates long-range magnetic ordering with a tiny ordered moment.

Figure 2 shows the the intensity difference between the data at 10 K (or 20 K) and at 130K for $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$ (y = 0, 0.06, and 0.12), where the intensity data is normalized by maximum peak intensity of nuclear diffraction. We found that the magnetic Bragg intensity does not depend on the Nb concentration. Given the randomness effect, that was a surprising result. More experimentation is needed to understand the Nb-doping effect for $Ba_3Zn(Ru_{1-y}Nb_y)_2O_9$.

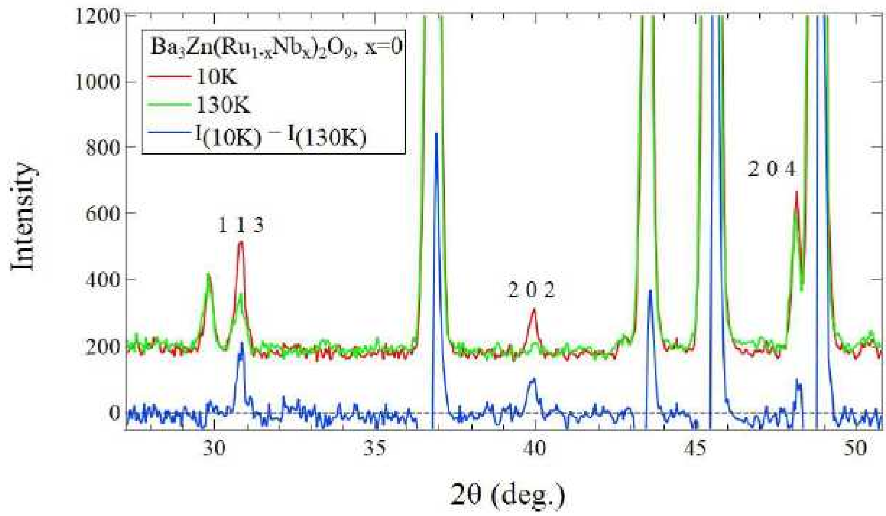

Fig. 1: Profiles of the neutron diffraction of $Ba_3ZnRu_2O_9$ taken at 10 K and 130K. Arrows indicate the magnetic Bragg reflections. Blue line indicates the intensity difference between the data at 10 K and at 130K.

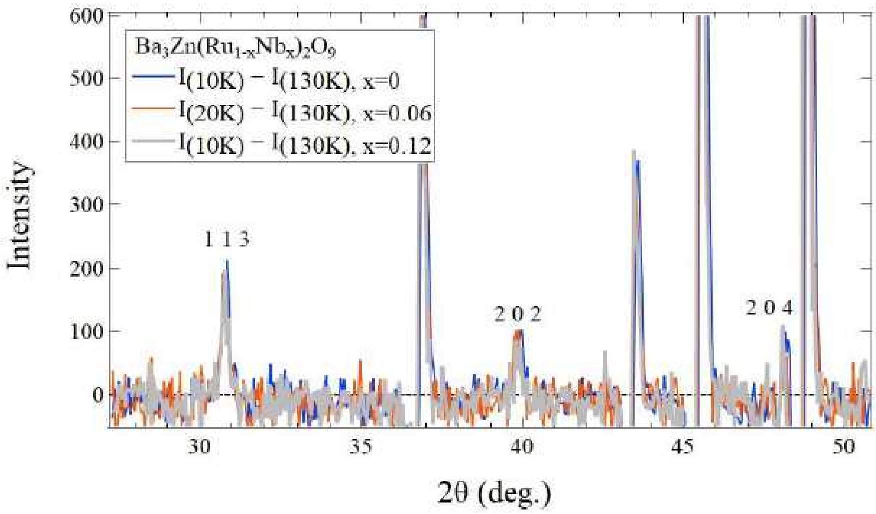

Fig. 2: The intensity difference between the data at 10 K (or 20 K) and at 130K for $Ba_3Zn(Ru_{1-x}Nb_x)_2O_9$ (x = 0, 0.06, and 0.12), where the data is normalized by maximum peak intensity of nuclear diffraction.

4． 引用(参照)文献等

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