実験報告書様式（一般利用課題・成果公開利用）

（ ※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。 ）

Experimental Report

提出日 Date of Report
October 15, 2012

課題番号 Project No.
2012A0057

装置責任者 Name of responsible person
Jun-ichi Suzuki

実験課題名 Title of experiment
Magnetism and Superconductivity in $Rb_xFe_{2-y}Se_2$

装置名 Name of Instrument/（BL No.）
TAIKAN/BL15

実験責任者名 Name of principal investigator
Kazuki Ohishi

所属 Affiliation
CROSS

実施日時 Date and time of Experiment
June 26 10:00-29 10:00, 2012 (60 hrs)
June 27: half-day operation

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。（適宜、図表添付のこと）
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Single crystalline samples of $Rb_xFe_{2-y}Se_2$

2. 実験方法及び結果（実験がうまくいかなかった場合、その理由を記述してください。）
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

The recent discovery of superconductivity in iron selenide compounds $A_xFe_{2-y}Se_2$ (A = K, Rb, Cs), with transition temperatures up to T_c ~ 32 K, has led to a renewed interest for iron based chalcogenide systems. AFe_2Se_2 has $ThCr_2Si_2$ type crystal structure, isostructural to the 122-type iron pnictides. However, from the neutron powder diffraction (NPD) study, it was found that the chemically stable phase of $A_xFe_{2-y}Se_2$ is mainly contributed by $A_{0.8}Fe_{1.6}Se_2$ with a fivefold expansion of the parent $ThCr_2Si_2$ unit cell in the *ab* plane and a $\sqrt{5} \times \sqrt{5}$ Fe vacancy order. The ordered Fe-vacancy structure is accompanied by a strong magnetic order, with a transition around T_N ~ 550 K. The spin structure consists of antiferromagnetically (AF) coupled four-site ferromagnetic blocks, with large on-site moments of 3.3 μ_B. The key issue in $A_xFe_{2-y}Se_2$ is whether AF order and superconductivity cohabit due to phase separation or share a microscopic coexistence.

We have performed μSR measurements in single crystalline samples of superconducting (SC) $Rb_{0.8}Fe_{1.6}Se_2$ (T_c = 29 K) and non-SC $Rb_{0.8}Fe_{1.6}Se_2$, in order to elucidate whether there is difference of magnetic state between the SC and the non-SC samples and to answer above question (coexistence or phase separation). As a result, we found that (1) SC volume fraction in the SC sample is only ~6% and the rest is AFM phase, suggesting SC and AFM ordering is separated. It is consistent with a result of Rb-NMR, which is done by our collaborators.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

(2) While no change in the μSR time spectra was observed in the SC sample, muon spin depolarization increases with decreasing temperature in the non-SC sample. It suggests the appearance of new magnetic state below 40 K, which is also consistent with Rb-NMR results, where the Rb signal disappears below ~40 K.

Our μSR and NMR results reveal two issues. (1) AF order and superconductivity cohabit due to phase separation. (2) New magnetic state appears below 40 K only in non-SC sample. Regarding the phase separation, it is suggested that the Fe or Rb-vacancies phase is ~300A domains. In order to clarify the domain size and volume fraction of each domain, we have performed small angle neutron scattering experiments at BL15/TAIKAN. We have prepared the SC and the non-SC single crystalline samples. The measurements were performed at the temperatures between 3 K and 300 K.

Figure 1(a) and (b) show the $I(q)$ vs. q obtained at 3 K and 300 K in the SC and the non-SC sample, respectively. At this moment, only 1m PSD data of small-angle bank were used. While the detailed analysis is still underway, we have found that no temperature dependence was observed both in the SC and non-SC samples. Fig. 1(c) shows $I(q)$ vs. q obtained at 3 K in the SC and the non-SC sample. Clear differences, as shown by circles, were observed. These differences correspond to the correlation distance of 100~200A and 6A. It might suggest the domain size of Fe or Rb-vacancies. To discuss the results quantitatively, we need to use and combine all banks' data, i.e., small-angle bank, meddle-angle bank, high-angle bank, and back-angle bank data, and reanalyze them. We are waiting for the completion of analysis software of TAIKAN to analyze our data.

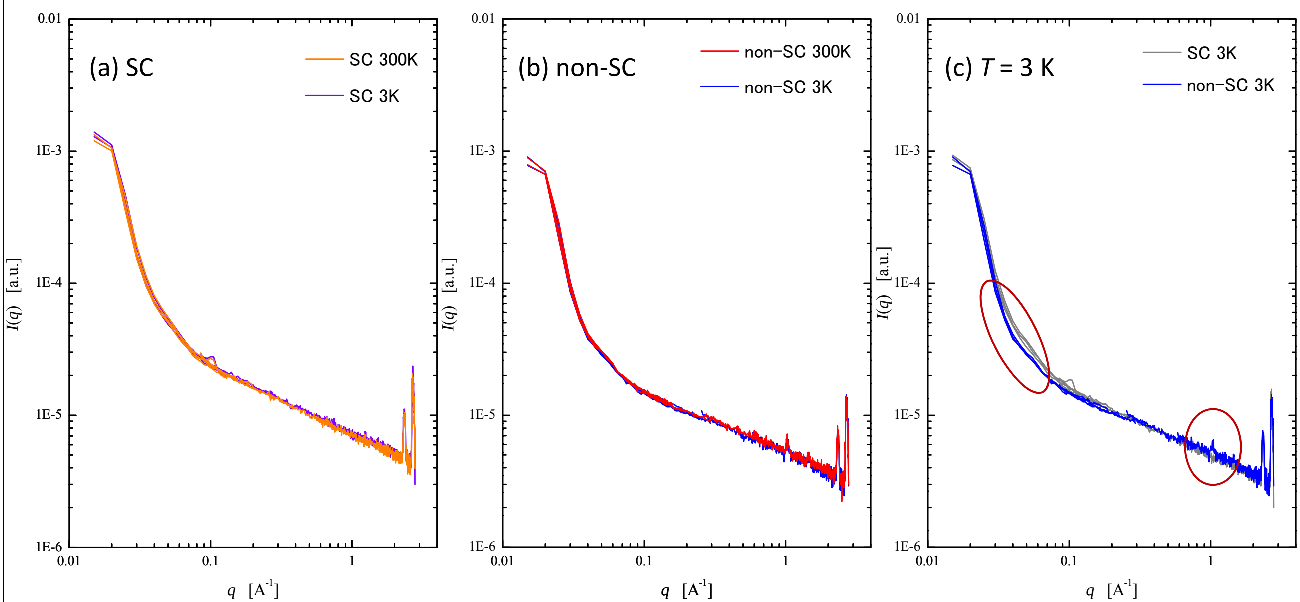

Fig. 1: $I(q)$ vs. q obtained in (a) superconducting (SC) sample and (b) non-superconducting (non-SC) sample at 300 K and 3 K. (c) $I(q)$ vs. q at 3 K for SC and non-SC samples.