Helical Vortex state on non-centrosymmetric superconductor $LaNiC_2$

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In superconductors with broken spatial inversion symmetry, where the crystal structure is not mirror-reversed in three-dimensional space, an unusual state called the helical flux state is thought to occur in the vortex thread state of a Type II superconductor catalytic systems for chemical reactions of gasses. Observation of the helical flux state is expected to lead to observation of the FFLO state. Hence, the observation of the helical flux state is the objective. We were able to observe the magnetic flux lattice signal of $LaNiC_2$ in an experiment performed at PSI in Switzerland in 2018. This time, we performed small-angle neutron scattering experiments using the same sample to reconfirm the signal of the magnetic flux lattice of $LaNiC_2$ and to observe the helical magnetic flux state of $LaNiC_2$ by performing small-angle neutron scattering experiments over a wide range of angles.

Single crystals of $LaNiC_2$ grown by Akiko Yoshikawa, RIKEN Strongly Correlated Materials Research Team, in 2018 were used. The single crystals were grown by the Choklarsky method. The single crystal of $LaNiC_2$ (Fig1) from the experiment performed at PSI in Switzerland in 2018 was rotated 90° counterclockwise and fixed (Fig2), so that the magnetic field was applied in the b-axis direction. However, analysis in grasp later revealed that the sample was installed in the dilution refrigerator with an 8° clockwise rotation when viewed from the direction of the magnetic field.

The sample was cooled using the ^3He-^4He dilution refrigeration method, in which ^3He and ^4He are liquefied respectively and the ^3He phase is poured into the ^4He phase to utilize the dilution heat. However, the circulation function of the dilution, which is a refrigerator, did not work well, and the mixing chamber temperature T_{MC} of the upper part of the sample in the dilution was T_{MC}=1.9K compared to the transition temperature Tc=2.7K of $LaNiC_2$, which was not enough for the superconductivity The experiment was conducted at T_{MC} = 1.9 K, which is not a sufficiently low temperature for an experimental environment in the superconducting state.

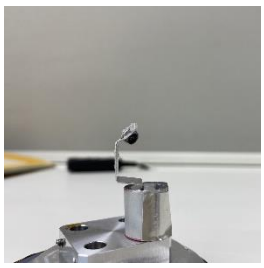

Fig1

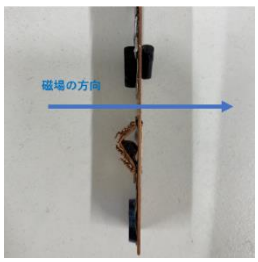

Fig2 The middle is $LaNiC_2$

In conclusion, we aimed to reconfirm the magnetic flux lattice signal of $LaNiC_2$ by small-angle neutron scattering and to observe the helical magnetic flux state of $LaNiC_2$ by small-angle neutron scattering over a wide range of angles, but both measurements were not sufficient to reconfirm the magnetic flux lattice signal. However, the results of both measurements were not sufficient to reconfirm the flux lattice signal. The helical flux state was also not observed. The main reasons for this are thought to be that the dilution refrigerator was not cooled sufficiently, making it difficult to observe the magnetic flux lattice in the superconducting state of $LaNiC_2$, and that it took time to deal with the problem with the dilution refrigerator, which prevented us from obtaining a sufficient amount of measurements. In the next measurement, we would like to reconfirm the signal of the magnetic flux lattice in a sufficiently cooled environment of $LaNiC_2$ and to observe the helical magnetic flux state.