Magnetic Domain Structure of Nuclear Ordered Solid Helium 3

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Solid ^{3}He has bcc crystal structure near the melting pressure at T~0. Below about 1mK, nuclear ordering into antiferromagnetic phase occurs. The spin structure in this phase is called U2D2 spin structure, where up-up-down-down spin sequence appears along its anisotropy axis (100). Due to this uniaxial anisotropy, U2D2 single crystal may have three kind of magnetic domains, each of which corresponds to either (100) or (010) or (001) anisotropy axis. Each kind of domains has different NMR resonance frequency, which reflects the angle between the anisotropy axes and the direction of an external magnetic field. Due to this fact, we could obtain the spatial distribution of magnetic domains by the Magnetic Resonance Imaging (MRI). We have developed the ULT-MRI, the MRI system applicable to the sample at ultra low temperature. By applying this technique, we obtained 3D distribution of the magnetic domains in a single crystal of U2D2 ^{3}He.

1. Each single crystal contains all three kinds of domains for most of the case. However a size of each domain is comparable to a size of the crystal. Thus only three or several domains are contained in a crystal. Although it is energetically unfavorable to have multiple domains for the antiferromagnet, we could not selectively melt the domains and obtain a mono-domain sample.
2. The domain wall between two adjacent domains is (110) plane for most of the case. This direction agrees with a theoretical expectation based on the multiple-spin-ring-exchange model, which is believed to describe the nuclear magnetism of U2D2 ^{3}He.
3. By applying a magnetic field, which is bigger than the critical field B_{c1}=0.46T, U2D2 phase disappears and another antiferromagnetic phase appears. This high field phase has a cubic spin symmetry with canted normal antiferromagnetic structure. Lowering the magnetic field produces U2D2 ^{3}He again. Quite surprisingly, the domain distribution in the U2D2 phase recovers more or less. The origin of this “memory effect” is under investigation.