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Negative muon spin rotation and relaxation study on antiferromagnetic order of Na clusters in sodalite

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μ^+SR is used in various research fields as a sensitive local magnetic probe. Although the implanted μ^+ stop at interstitial sites in the crystal, it is often difficult to determine the sites precisely. On the other hand, the implanted μ^- are captured by nuclei and have different lifetimes for each nuclide. Thus, the μ^- position is unambiguously determined by measuring the lifetime. However, the spin polarization of μ^- is reduced down to about 1/6 during the capture process, requiring much higher statistics than μ^+SR. Recent improvements in the beam intensity and detection efficiency of pulsed-muon facilities have made μ^-SR experiments feasible, and such an advanced μ^-SR is used to study ion dynamics in solids.[1] We here report an attempt to investigate magnetic materials with the advanced μ^-SR.
Na_4^{3+} clusters can be arranged in a bcc structure in sodalite crystal. Antiferromagnetic ordering occurs below $T_N = 50$ K due to the exchange interaction between the s-electrons in the arrayed clusters. In ZF-μ^+SR, a homogeneous local field of 92 Oe is observed at low temperatures.[2] Our recent study shows it's due to the Fermi contact at the cage center. In the present μ^-SR, the lifetime analysis shows the signal at the oxygen site is dominant. The initial asymmetry of the time spectra dropped sharply below T_N, but muon spin precession due to a homogeneous local field couldn't be observed. The decoupling by longitudinal field shows the local field of about 0.4 kOe. This value can be explained as the local field of oxygen sites when the spatial distribution of s-electron wave function is approximately incorporated. These results demonstrate the importance to study the magnetic nature of materials with $\mu^{\pm}$SR.
[1] I. Umegaki *et al.*, J. Phys. Chem. C **126**, 10506 (2022).
[2] R. Scheuermann *et al.*, Phys. Rev. B **66**, 144429 (2002).

Primary author: Prof. NAKANO, Takehito (Ibaraki University)

Co-authors: Mr BABA, Hiroyuki (Ibaraki University); TAKESHITA, Soshi (High Energy Accelerator Research Organization (KEK)); SUGIYAMA, Jun (CROSS Neutron Science and Technology Center)

Presenter: Prof. NAKANO, Takehito (Ibaraki University)

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