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Negative muon spin relaxation in water and ice

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Muons are the main component of cosmic ray particles on the earth, and most of the cosmic ray muons are injected into water or ice, which occupy more than 70% of the earth's surface. When negative muons (μ^-) stop in H_2O, they are mainly trapped by oxygen nuclei and form muonic oxygen atoms $O\mu^-$, and about 15% of $O\mu^-$ atoms finally change to stable nitrogen isotopes ^{14}N or ^{15}N via the neutron emission after the muon capture process. The nitrogen isotopes produced by such a process may be chemically active due to their high recoil energy and may form various nitrogen compounds through reactions with water molecules. In this situation, μ^-SR spectroscopy is suitable for studying the behavior of such active nitrogen in H_2O, since $O\mu^-$ atoms also act chemically as nitrogen. In the present study, we measured μ^-SR spectra in water and ice to approach what kind of nitrogen compounds are formed by cosmic-ray negative muons, and how they affect the surrounding chemical environment.
Experiments were carried out at the D1 beamline in the Materials and Life Science Experimental Facility (MLF) of J-PARC. H_2O and D_2O samples were irradiated with a negative muon beam (47 MeV/c, double pulse), and ZF and LF-μ^-SR spectra were measured. The result shows that the relaxation due to the nuclear dipolar field is observed in solid H_2O and D_2O at 200 K. The field distribution widths were deduced to be Δ_H=0.27 μs^{-1} and Δ_D=0.066 μs^{-1}, for H_2O and D_2O respectively. The relationship between these two values is well explained by the difference in the spins and magnetic moments of proton and deuteron.
In this conference, we will discuss possible chemical states based on the present results.

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