Study on the water detection by neutron spectroscopy for future lunar landing explorations

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The water-ice at the lunar polar regions is important from the viewpoint of scientific interest and future lunar utilization. According to some theoretical suggestions, water and other volatiles could be delivered to the Moon by comets and/or the solar wind, and they might be accumulated and trapped at cold spots as the permanently shadowed areas. Although several remote observations have indicated the presence of water-ice in lunar polar regions, its abundance and spatial distribution are still controversial issues.

Recently, in Japan and other countries, lunar landing explorations at the polar region are being studied in order to obtain the abundance and distribution of water in the subsurface and to reveal the accumulation mechanism of water. The neutron spectroscopy is one of the best methods for in-situ water detection on the airless planetary surface. The galactic cosmic rays generate fast neutrons via nuclear spallation interaction in the subsurface materials at a depth of several tens centimeters. Then the fast neutrons are moderated to thermal and epithermal neutrons by interactions with subsurface materials, and this process is terminated at the thermal neutron capture or leakage of neutrons from surface. Since the hydrogen atom has a large elastic scattering cross section for a neutron and a nearly identical mass as a neutron, the neutrons are efficiently moderated by the elastic scattering with hydrogen atoms. Therefore, the leakage neutron flux strongly depends on the hydrogen abundance as well as the chemical composition of surface materials.

In this study, the in-situ water detection by neutron spectroscopy on the lunar polar landing exploration has been investigated by the numerical simulation. The fluxes of thermal, epithermal, and fast neutrons generated by galactic cosmic rays were calculated for different hydrogen abundance in the lunar polar material. The dependence of neutron fluxes on the spatial distribution of hydrogen were also studied on the several patterns of distribution. In addition, the neutron detection efficiency was estimated by assuming multiple neutron detectors in order to select and optimize the neutron spectrometer. An Li-glass scintillator, a B-loaded plastic scintillator, and a ^{3}He proportional counter were considered as neutron detectors. The preliminary calculation results will be presented, and the detection capability of water on the lunar landing exploration will be discussed.

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