Science with the Alpha Ray Detector on-board SELENE

Katsuhisa Furuichi[1]; Toshisuke Kashiwagi[2]; Takeshi Takashima[3]; Shoji Okuno[2]; Kenji Yoshida[2]; Masayuki Itoh[4]; Kunishiro Mori[5]; Jun Nishimura[6]

[1] Human Environment Sci. Kobe Univ; [2] Faculty of Engineering, Kanagawa University; [3] ISAS/JAXA; [4] Faculty of Human Development, Kobe Univ; [5] CLEAR PULSE Co.; [6] ISAS

Alpha Ray Detector (ARD) will be on-board SELENE. The ARD investigates the gas emission on the lunar ground through alpha particle observations. In this paper, we discuss science with the ARD as well as its expected performance.

Experiments in the past detected alpha particles from 222Rn (5.490 MeV) and from 210Po (5.305 MeV). These are members of 238U radioactive family. Since the alpha particles have very short range and cannot penetrate the lunar crust, they are observable only when the emitting nuclei exist in the lunar atmosphere or on the lunar surface. Some of the 222Rn nuclei produced in the ground move up to the lunar surface through cracks in the crust with other gaseous material. They decay with the half life of 3.8 days emitting the alpha particles. The daughter nuclei deposited on the lunar surface experience sequence of decays, and 210Po nuclei emit alpha particles. The time span of the decay sequence is dominated by 210Pb of which half life is ~22 yr. Thus, the alpha particles from 222Rn can be an indicator of the real-time gas emission and those from 210Po carry information on the gas emission over the last ~20yr.

Measurements of the alpha particles were carried out by Apollo 15 and 16, and Lunar Prospector (LP), which produced a global map of the alpha particle intensity. Results of these experiments indicate that the gas emission has both spatial and temporal variability. In general, distributions of the alpha-particle intensities from 222Rn and 210Po are largely different. An exception is the Aristarchus Crater region where both 222Rn and 210Po alpha particles showed an intensity peak. This region is also known to have high abundance of 232Th from gamma-ray observations and may have some key information on the crustal abundance and structure. One of the most noticeable results is the Mare Edge Effect that the 210Po alpha particle intensity increases around the boundary of mare and highland regions. Since the crust around the mare edge region tend to have cracks due to the basin formation, the observed effect may imply the enhanced gas emission through such cracks. Gamma-ray spectroscopic observations of the lunar surface revealed concentrations of 232Th and 238U, and the distribution of 222Rn and 210Po alpha-particle intensity is expected to have some correlation with those material. If the lunar crustal structure is influenced by the tidal effect or large temperature difference between the daytime and nighttime, gas emission at around the day-night transitions may be observed.

The ARD consists of 48 silicon SSD chips each of which has 26x26 mm2 area and 100-micron thickness. Energy resolution of about 100 keV (FWHM) was achieved by the development of low-noise pre-amplifier, which enables clear resolution of the alpha particles form 222Rn and 210Po. Total effective area is 326cm2, which is 21 times larger than Apollo and 18 times larger than LP. The field of view of the detector is limited to ~80 degrees (bottom to bottom) with collimators, which corresponds to ~160 km on the lunar surface. High background-rejection efficiency of more than ~90% will be achieved by the anti-coincidence method. The mission period of SELENE is at around the solar minimum, which also contributes to the high S/N. We expect the cosmic-ray background level of ~0.2 ct/min (in 200keV band) and the background due to the albedo proton of ~0.9 ct/min. Estimate of the average count rate is ~0.2 ct/min for 222Rn and ~10 ct/min for 210Po while the peak count rate is ~20 ct/min for both.

After the mission period of one year, we will obtain a result of which spatial resolution is 4 times higher than LP. Data accuracy will be much improved because SELENE is the 3-axis controlled spacecraft while LP is the spin stabilized. Thus, the observations with ARD will enable us to determine the distribution of the radio-active material and gas emission location with high accuracy as well as to detect time variations.