GRB221009A AND OTHER GAMMA-RAY MONITORING DATA IN DEEP SPACE BY KPLO GAMMA-RAY SPECTROMETER

K. J. Kim[1,2], S. Y. Kim[1,2], Y. Choi[1], J. H. Park[1], Y. K. Kim[3], K. S. Park[3], K. B. Lee[4] and the KGRS Team, [1]Korea Institute of Geoscience and Mineral Resources, Daejeon, 34132, [1]Republic of Korea, Resource Engineering, [2]University of Science and Technology, Daejeon, Republic of Korea, [3]Nucare(Inc), Osong, Republic of Korea, and [4]Korea Research Institute of Standards and Science, Daejeon, Republic of Korea

Introduction: The KPLO orbiter (Danuri) was launched by a SpaceX Falcon 9 rocket from Cape Canaveral Space Force Station on August 5, 2022(KST). The Danuri orbiter is carring six scientific instruments including a gamma-ray spectrometer (KPLO Gamma-Ray Spectrometr, KGRS). The KPLO's lunar trajectory is a low-energy, fuel-efficient ballistic lunar transfer (BLT) trajectory. The KPLO has arrived to lunar orbit of an altitude of 100 km on December 27, 2022. During the cruise period of 4 months and 3 weeks, The KGRS was monitoring both gamma-ray burst and background as scientific objectives in deep space.

KGRS instrument: The KPLO Gamma-Ray Spectrometer (KGRS) is a compact low-weight instrument for the elemental analysis of lunar surface materials within a gamma-ray energy range from ~30 keV to 12 MeV. The major components of KGRS consist of a primary $LaBr_3$ gamma-ray detector with an anti-coincidence counting module of 5% boron-loaded plastic scintillator to reduce both gamma-ray background from the spacecraft and housing materials, and cosmic ray background. The science goals of KGRS are associated with investigations of both lunar geology and lunar resources down to a half-meter depth of the lunar surface. Because the KPLO took the BLT trajectory to arrive to the Moon, KGRS was able to collect signals of gamma-ray burst (GRB) with five different energy intervals as well as two gamma-ray background spectra from high-gain and low-gain signals from the main sensor, $LaBr_3$ and a spectrum from the shielding detector, BLPS for every 10 sec.

$LaBr_3$ intrinsic gamma-ray background: Figure 1. shows the gamma-ray background spectrum of KGRS in deep space. The main sensor of KGRS is made of $LaBr_3$ which has intrinsic gamma-ray backgound of ^{138}La and ^{227}Ac radioisotopes. Measuring gamma-ray backround in deep space gives a merit of checking the self-activity of $LaBr_3$ without any background interference in a laboratory environment. The gamma-ray background on the Moon by facing to deep space is expected to be different from deep space because the lunar environment has gamma-ray background level could be higher interacting made by the solar wind and surface of the Moon. Obtaining both gamma-ray background from deep space and on lunar orbit will give a better understanding in backgound sources in KGRS data processing.

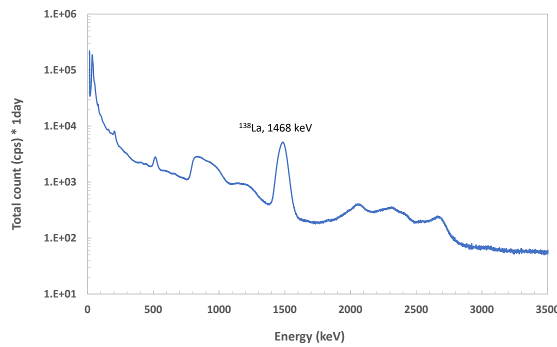

Figure 1. Gamma-ray spectrum of KGRS in deep space on Oct. 09, 2022.

Monitoring of GRB221009A by KGRS: Gamma-ray bursts (GRBs) are the most energetic explosions knownto humankind. Although discovered in 1967 [1] by the Vela Satellite Network, the physics of GRBs still remains unsolved. There were a number of gamma-ray burst signals collected by KGRS for the cruise period. Especially KGRS has been designed to measure GRB counting variation with 5 channels that correspond to 5 energy intervals (35-65, 65-123, 35-123, 123-418, 418-3607 keV). There are two gamma-ray monitoring missions. Integral Gamma-Ray Observatory was lauched in 2002 to reach a highest operational orbit of Apogge height 153,657 km and Perigee height of 9,050 km. for measuring gramma-ray energy range 15 keV to 10 MeV [2], and Fermi Gamma-Ray Space Telescope was launched in 2008 to an orbital altitude of 550 km for detecting gamma-rays from ~ 8 keV to ~ 40 MeV [3]. The gamma-ray burst collection time by KGRS is set to be every 10 sec. During August 13 to December 10, 7 GRB records of KGRS were matched with the GRB records found in the NASA's Swift website. The strongest gamma-ray burst detected by KGRS is GRB221009A. The location and time of KPLO when the KGRS collected the gamma-ray signal was a distant location of 1,508,160 km on October 9, 13 pm (UTC). The farthest distance for KPLO reached was 1,550,000 km (Fig. 2). The gamma-ray intensity of GRB221009A was as high as 98 time from the background level although it is different in enegy interval settings (Fig. 3). The KGRS's GRB221009A signal is well compared with other publicly reported gamma-ray monitoring data.

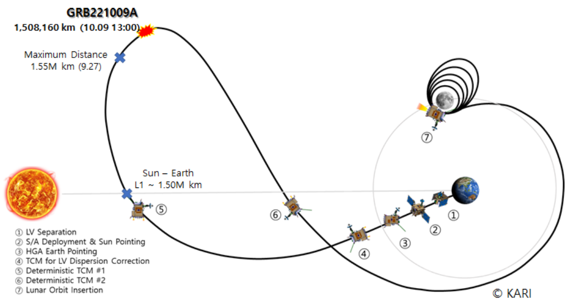

Figure 2. Location of KPLO when KGRS measured gamma-ray signals of GRB221009A.

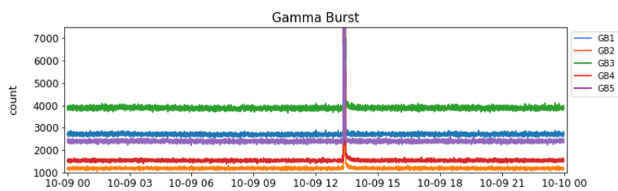

Figure 3. Gamma-ray counting data (in 10 sec) as a function of clock time on October 9, 2022. The GRB221009A is collected at 13:21 (KST) for approximately for 6 minutes.

Gamma-ray Background Meausrement: During the cruise period, KGRS detected significantly increased gamma-ray counts for all gamma-ray energy regions during the periods from Sept 13 ~ Sept 15 and Oct 1 ~ Oct 4. Figure 4 shows the the total gamma-ray count variation on October 2. It was found that the gamma-ray counting rate during this period were increased as much as a factor of 2 than background values. Also, it was found that there were relatively increases of solar x-ray flux during the periods based on the data from solarmonitor.org [4]. On the Moon, checking gamma-ray flux variation all the time is important in order to identify sources of incoming gamma-rays registered to the KGRS sensor unit for reliability of lunar GRS mapping. During the curise period, this issue has been alerted with the significant increased GRS background for few days. Therefore, daily monitoring gamma-ray counting data is necessary to identify sources of gamma-ray background on the Moon.

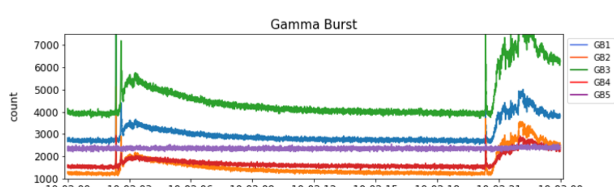

Figure 4. Gamma-ray counting data for October 2, 2022.

Discussion: The KGRS detected a strongest gamma-ray burst on October 9, 2022 in deep sapce and also identified gamma-ray backgound count increases for few days. The latter case needs to be carfully monitored and eliminated from the lunar gamma-ray data collection. The data collected by KGRS during 4 months and 3 weeks of the cruise period is invaluable as a reference data for gamma-ray burst detection, self-radioactivity of $LaBr_3$, and gamma-ray background in deep space.

Acknowledgments: This study was supported by research projects (KIGAM, 21-6801: 2016M1A3A9913307 and KIGAM, 23-3216) of the Korea Institute of Geoscience and Mineral Resources funded by the Ministry of Science, ICT.

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