

**Initial Operation of the KPLO Magnetometer (KMAG).** Ho. Jin<sup>1</sup>, Khan-Hyuk Kim<sup>1</sup> and Ian Garrick-Bethell<sup>2</sup>,  
<sup>1</sup>Kyung Hee University (benho@khu.ac.kr), <sup>2</sup>University of California, Santa Cruz (igarrick@ucsc.edu)

**Introduction:** KMAG is one of the science instruments of the Korea Pathfinder Lunar Orbiter (KPLO) mission. Its objectives are magnetic field investigation and technical demonstration in near-Moon space. We expect that it will investigate the lithospheric magnetism of the Moon during an extended mission and measure electromagnetic wave properties. It consists of three fluxgate magnetometers on a 1.2-m-long boom (Fig 1). The three magnetometers are included for scientific measurements, redundancy checks, and multi-sensor technical investigation [1]. The sampling rate is 10 Hz and the three magnetometers are operated simultaneously. The deployed boom angle is 135° from the KPLO top panel (Fig 2). Previous lunar magnetic field observations were made by Lunar Prospector [2] and KAGUYA [3].

KPLO took a slow, looping Ballistic Lunar Transfer (BLT) orbit en route to the Moon. So we had a chance to observe magnetic fields in the solar wind space for 4.5 months. As of January 2023, KPLO is in a  $100 \pm 30$  km circular lunar orbit. We hope that this instrument will contribute to the study of lunar magnetic fields.

**KMAG Instrument:** The fluxgate control electronics (FCE) has 4 boards, which have CubeSat standard dimensions. These electronics boards are made with commercial grade electronics parts except the spacecraft interface connectors and wires. The fluxgate magnetometers consist of three racetrack shape sensors. Additionally, one magnetoresistive-type sensor (HMC1053) is in the FCE box. The Flight model showed that the magnetometer noise level was less than  $30 \text{ pT Hz}^{-1/2}$  at 1 Hz and stability was within  $\pm 0.2$  nT. Total mass and power consumption is 3.5 kg and 4.6 watt, respectively.

**Observations:** KMAG operation has a 100% duty cycle, which means that it is a non-stop observation, except during the spacecraft's special request. The KMAG Observation started 4 hours after launch. Therefore we could detect the Earth magnetopause and bow shock during KPLO's BLT journey (Fig 3). For the BLT cruise phase, KMAG operation was continuous.

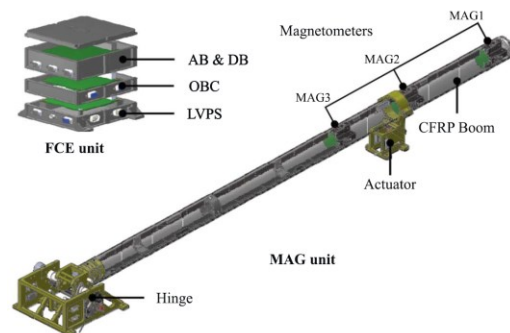
During BLT cruise phase, KMAG carried out on-orbit calibration and data analysis with the NAIF SPICE toolkit [4]. To check data reliabilities, we compared between the KMAG data set and DSCOVR mis-

sion data. Because the DSCOVR mission is in the L1 point, we do this analysis when KPLO is near L1 on the Sun - Earth line (Fig 4).

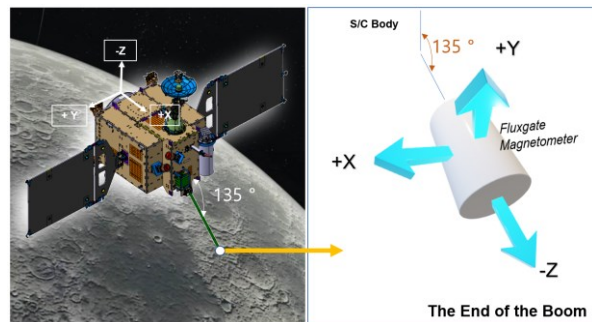
**Data:** In the present  $100 \pm 30$  km lunar circular orbit, the MAG1 temperature gradient shows  $0.23 \text{ }^{\circ}\text{C}/\text{min}$  between a  $-16 \text{ }^{\circ}\text{C}$  and  $-6 \text{ }^{\circ}\text{C}$  temperature range. This temperature gradient is the same as several ground test conditions. Therefore, while we use a temperature offset adjustment during calibration, this temperature variation range is not a critical issue. The electronics box temperature is very stable.

Magnetic field interference was clearly observed during spacecraft activities. Most interferences are well distinguished by multi-sensing data sets. However, since there are a lot of different shapes of magnetic field interference, we carry out our analysis on data with clearly identifiable features

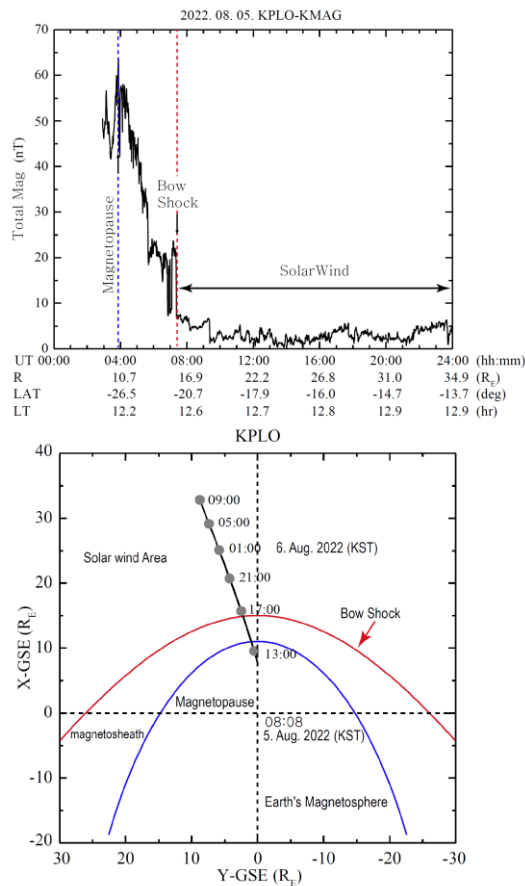
The offset value is quite different than we expected. We think that some metal parts of the boom structures may have been magnetized while KMAG was on the ground for two years.



**Fig. 1.** KMAG configuration: MAG unit and FCE unit. Three fluxgate magnetometers are located inside the boom, and MAG1 at the end of the boom is the primary magnetometer.



**Fig. 2.** KMAG boom deployment angle is 135 degree. The boom deployed 3 hours after launch.



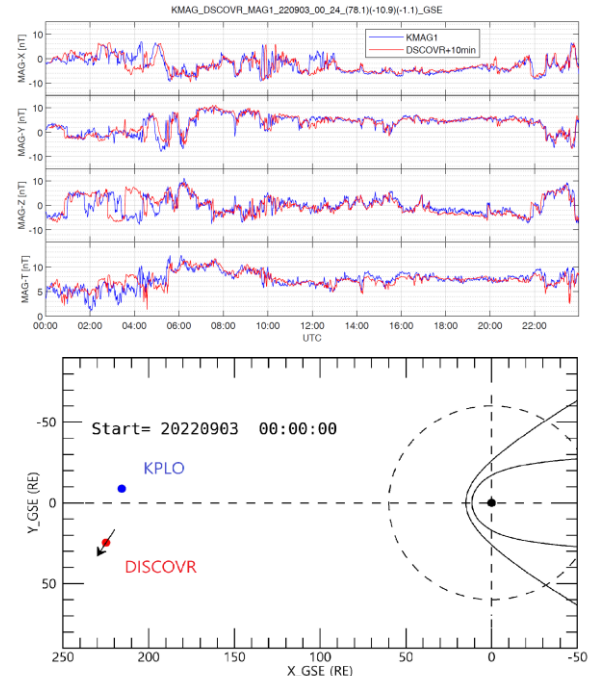
**Fig. 3.** K MAG observations start after boom deployment. Red and blue lines are drawn based on a model.

#### Current status and future plan:

After launch on 04 August 2022, KPLO reached the Moon after 4.5 months of travel. KPLO is operating in a  $100 \pm 30$  km circular orbit from 27 Dec 2022 until now. Due to other instrument operations, the spacecraft attitude changes frequently, and we are continuously monitoring its influences.

There are still some analysis issues such as noise, distortion from the spacecraft body and offset verifications. Fortunately, the ARTEMIS-P1, P2 missions are also carrying out observations near the Moon in highly elliptical orbits. Therefore we will examine these issues with a multi-sensing method including comparison between K MAG and ARTEMIS.

K MAG observational data (partially processed) would be released around mid-2023 at the KPDS KARI (Korea Area Research Institute).



**Fig. 4.** K MAG data comparison with DSCOVR (03. Sept. 2022) and their positions in the solar wind region. DSCOVR data is 10 min shifted to match K MAG.

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