THE FUTURE JAPANESE CBR ANISOTROPY OBSERVATORY AT THE MOON

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Abstract. We have a plan to a radioastronomy mission at the Moon. This is dedicated to the mapping of the CBR anisotropy in order to study the properties of the early Universe, especially galaxy formation. This is a candidate for the Moon mission of NASDA, launched by an HIIA Rocket. The mission carries an 1.5 m (min.) offset parabola antenna with radiation shield to the north polar region of the Moon. This will observe CBR anisotropy at three (min.) frequencies between 30 to 90 GHz. The angular resolution is 9' at 90 GHz. The telescope will observe the donut-shaped sky between 5 to 30 degree (not fixed) from the Moon celestial north pole. The resultant sensitivity will reach $\Delta T/T \simeq 10^{-6}$K in 30'×30' pixel and $\Delta T/T \simeq 10^{-5}$K in 9'×9' pixel.

1. The Moon is the good site for radioastronomical observation?

According to the standard scenario of the evolution of the Universe, the fluctuation of matter makes various structures in the Universe. They can be observed through the anisotropy of CBR. Figure 1 shows current status of observations of CBR anisotropy[1].

The large angular scale anisotropies have been observed by COBE[2]. However, the small angular scale anisotropies are now confusing because of the difficulty of these observations. The first advantage of observations from the Moon is that the observations are free from additional noise and attenuation of Earth atmosphere. The additional noise is 10^7 times larger than the expected signal when the CBR anisotropy is observed by ground-based telescopes. This is given for all observations in space. The second advantage is that the telescope can be located in the cold and quiet environment. The Moon polar region is expected to be cold and quiet. The telescope picks up additional noise from Earth, Sun and Moon surface through antenna spill-over. In the Moon polar region, the maximum elevations of Earth and Sun are lower than 15 degree. In addition, the positions of the Earth and Sun are quite gradually changed. These make the subtraction by beam-switching method effective. The night time is 15 days on the Moon. The temperature of the Moon surface in the night time is much lower than 150 K. This fairly reduces the contamination from the Moon surface. However, the long night is not good for power supply. The Moon is the good site for sensitive radio observation.

2. Mission Overview

Our mission is a candidate for the Moon observatory of NASDA, launched by an HIIA Rocket. The mission carries a sensitive radiotelescope dedicated to CBR anisotropy observations to the north polar region ($\simeq 85°$) of the Moon.

J. Andersen (ed.), Highlights of Astronomy, Volume 11B, 992–995.

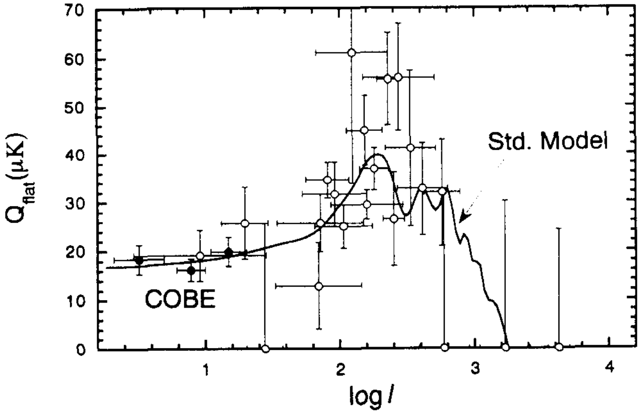

Figure 1. Current status of observations of CBR anisotropy

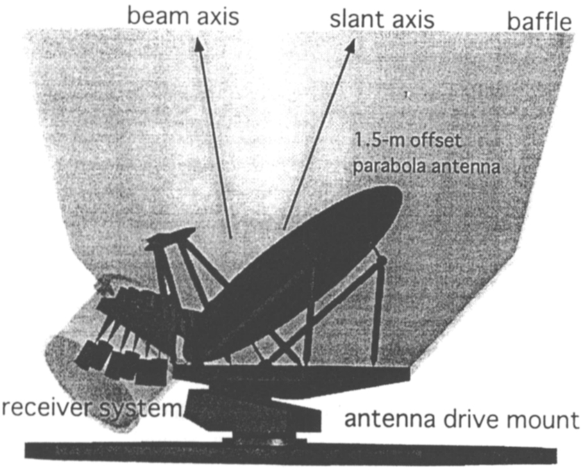

Figure 2. A schematic display of the Moon observatory

Unfortunately, the launch year will be fairly later than 2000, the launch year of MAP, and 2005, the launch year of PLANCK, if the proposal is accepted. Thus, the scientific objective of our mission is deeper and smaller angular scale CBR anisotropy observations for the selected area.

Figure 2 shows a schematic display of the Moon observatory. The antenna is an oversize offset parabola antenna with radiation shield (baffle) in order to suppress side-lobe level. The effective antenna diameter is 1.5. (min.). The baffle will reduce far side-lobes below -90 dB[3]. The baffle also shields the antenna from the Sun. The antenna is cooled to 100 K by radiative cooling. Therefore, the telescope in the polar region can observe CBR even in day time. This telescope has three (min.) pairs of HEMT differential radiometer.

Figure 3 shows the block diagram of the radiometer. This will observe CBR anisotropy at three (min.) frequencies between 30 to 90 GHz. Three frequencies are required for subtraction of the Galactic foreground. The angular resolutions are 28' at 30 GHz, 17' at 50 GHz and 9' at 90 GHz, respectively. The angular resolution at 90 GHz is 2 orders better than COBE-DMR. The 90 GHz band is located in the window between thermal emission and dust emission in our Galaxy. The HEMT amplifiers are cooled to 40K by a Starling-cycle mechanical refrigerator. The system noise

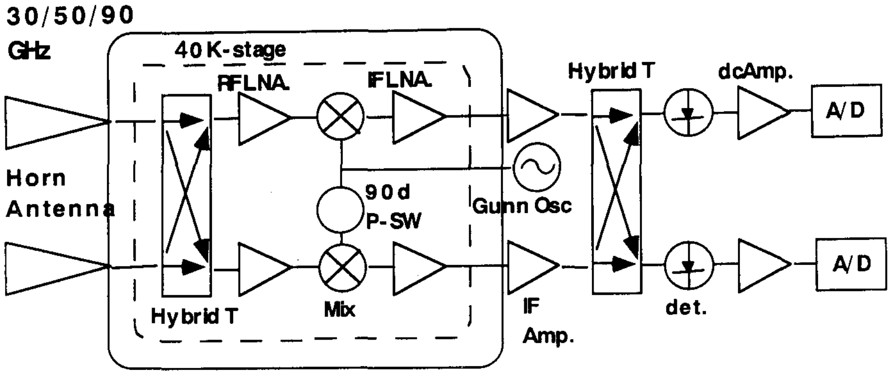

Figure 3. Block diagram of the radiometer of the Moon observatory

TABLE 1. Mass budget of the Moon observatory

main reflector + sub reflector	30 kg
baffle	70 kg
horn antennas	10 kg
antenna mount	50 kg
receiver system	30 kg
power supply system	300 kg
lander	800 kg
Total	<1.5 ton

temperature are 30K at 30 GHz, 40K at 50 GHz, respectively. The bandwith is 10% of the observing frequency.

Figure 4 shows the mapping method of our telescope. The telescope makes active scan along a small circle on the sky by antenna rotation of 0.3 r.p.m. around a slant axis. The telescope will observe the donut-shaped sky between 5 to 30 degree (not fixed) from the Moon celestial north pole by the combination of the active scan and the drift scan by the Moon rotation. The sky coverage is 6% of the total sky area. Mission life time is 36 (min.) months. The resultant sensitivity will reach $\Delta T/T \simeq 3 \times 10^{-6}/28'$ beam, $\Delta T/T \simeq 5 \times 10^{-6}/17'$ beam and $\Delta T/T \simeq 9 \times 10^{-6}/9'$ beam, respectively. Table 1 and 2 summarizes mass budget and power budget of the mission, respectively. Total payload mass is 1.5 ton. The science instrument including power supply is 700 kg. The long night requires huge mass, 300 kg, for power supply, although the total power of the mission is below 100 W.

TABLE 2. Power budget of the Moon observatory

antenna driver for active scan	10 W	
receiver system	20 W	(=15 W (oscillators) + 5W (amplifiers))
Starling-cycle refrigerator	35 W	
signal processor/computer	5 W	
others	20 W	
Total	<100 W	

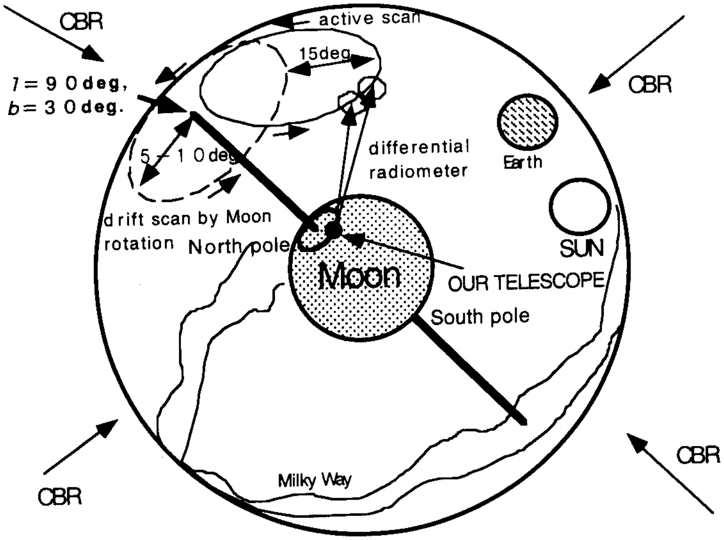

Figure 4. The mapping method of the Moon Observatory

References

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2. Smoot, G. et al., Astrophys.J., 396, L1, (1992)
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