【Grant-in-Aid for Specially Promoted Research】

Probing the origin of the universe using the largest CMB telescope arrays to date

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Project Information	Project Number : 22H04913　　Project Period (FY) : 2022-2026 Keywords : Cosmic Microwave Background (CMB), Inflation, Primordial Gravitational Waves, Neutrino

Purpose and Background of the Research

●Outline of the Research

Observations of the oldest light in the universe, the Cosmic Microwave Background (CMB), allow us to experiment on the origins of spacetime and matter. In particular, precise measurements of the spatial patterns in the CMB's polarization component probe various science topics: quantization of the gravitational field, cosmic inflation, grand unified scale, and absolute mass of the neutrinos. As shown in Figure 1, the Simons Observatory will explore these sciences through deploying the world's largest CMB telescope arrays.

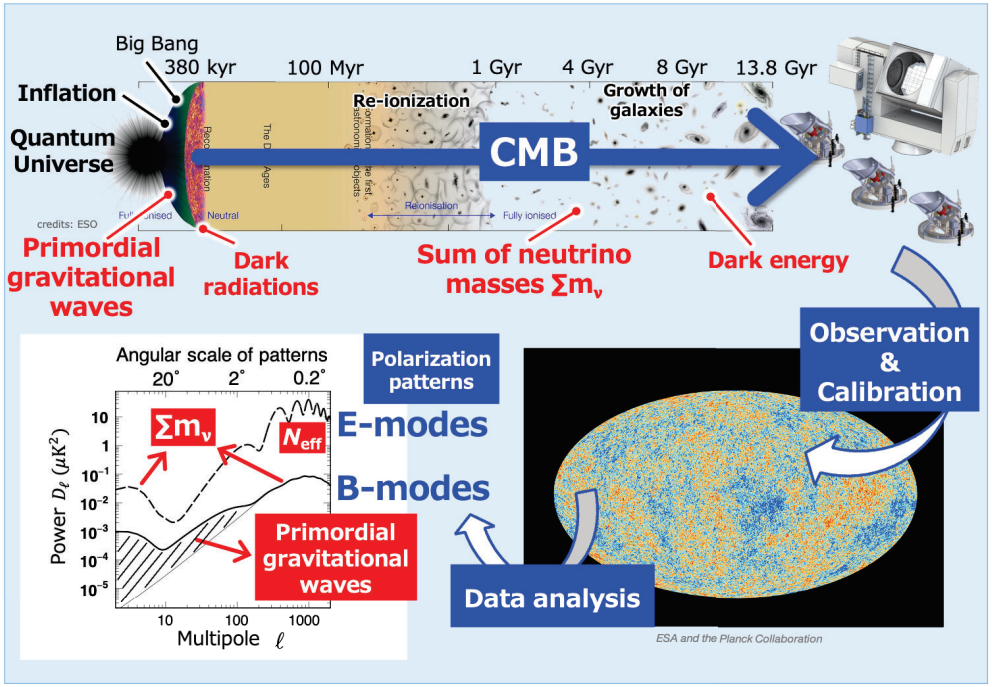

Figure 1. Overview of this research. Through the observation of the CMB, we aim to study these "high-impact" science topics to prove "the begin of the universe".

●Research Strategy

A hybrid strategy of developing two types of telescopes, separately optimized for large and small angular scale observations, allows us to explore all the science topics above. Moreover, the telescope arrays allow for observations with many frequency bands while maximizing sensitivity through implementing 60,000 detectors.

●Past Achievements Prior to This Research Program

Based on grants, e.g., KAKENHI Basic Research (S), we developed the CMB telescopes used in this research as shown in Figure 2. In particular, the Japanese group has been in charge of the "cryogenic optics tubes" and calibration systems for each telescope.

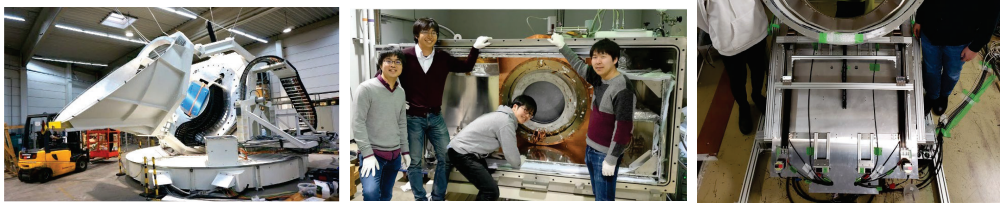

Figure 2. Instrumental achievements prior to this research: telescope mount, cryogenic optics tube, and calibration system.

Expected Research Achievements

●Observation of CMB Polarization with The World's Best Sensitivity

Within the term of this grant, we will start CMB observations with the world's best sensitivity, and develop instrumental calibration and data analysis techniques for the most sensitive search of primordial gravitational waves (PGW) and unique studies related to particle physics, e.g., measurement for the sum of neutrino masses.

●Impacts of High Sensitivity Study of Primordial Gravitational Waves (PGW)

For the detection of the PGW, we have prospects to achieve ten times better sensitivity than past experiments to date (Figure 3). A discovery of the PGW is evidence for the quantization of the gravitational field in the early stage of the universe, and is "smoking-gun" evidence for cosmic inflation. It is an important hint for quantum gravity and indicates that the potential energy of inflation corresponds to the grand unified theory (GUT) scales in particle physics.

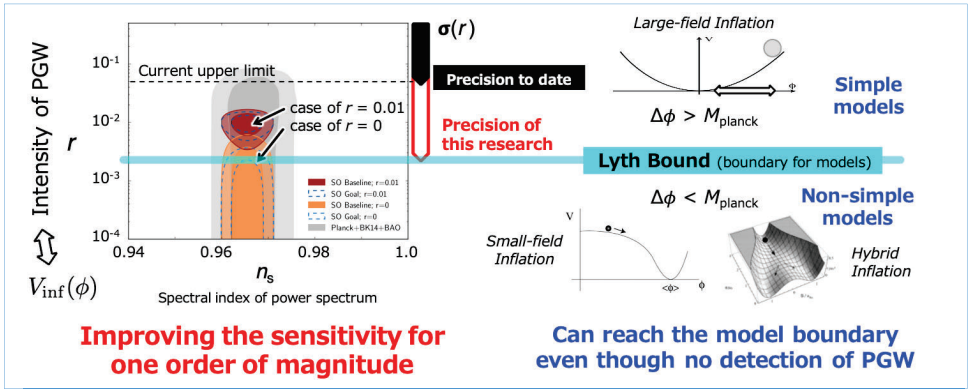

Figure 3. Scientific impacts of this research for the study of the primordial gravitational waves (PGW) and cosmic inflation.

●Impacts of Study for Beyond The Standard Model (BSM) in Particle Physics

BSM physics can be studied, e.g., further understanding the absolute mass of the neutrino which is one of the probes for accessing GUT. This proposal provides broad impacts for particle physics as well as cosmology.

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