【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

**Title of Project : Quest for the origin of the Big-Bang and measurements of sum of the neutrino masses by using the world's largest CMB telescope array**

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Research Project Number : 17H06134 Researcher Number : 80391704
Research Area : Cosmology and high energy physics
Keyword : Cosmology experiment, Cosmic Microwave Background radiation

## 【Purpose and Background of the Research】

Cosmic Inflation is the modern cosmology which describes the origin of the Big-Bang in the early stage of the universe. Many cosmological observations support this theory. The last piece to prove this theory is the detection of the primordial gravitational waves (PGW). As shown in Figure 1, PGW generate characteristic imprints in the polarization patterns of the cosmic microwave background radiation (CMB). These odd-parity patterns are called "B-modes", and it particular degree-scale B-modes are considered to be the best probe of PGW. The sub-degree scale B-modes can also probe the weak lensing effect caused by galactic clusters. Because neutrinos are unique massive particles that are not localized within galaxies, the weak lensing effect is sensitive to the sum of neutrino masses ($\Sigma m_\nu$). Therefore, precise measurements of the B-modes can potentially detect PGW and constrain $\Sigma m_\nu$ (see Figure 1 and 2). We will pursue these two main research targets with the world's largest next generation CMB telescope array experiment, ``Simons Observatory" (SO).

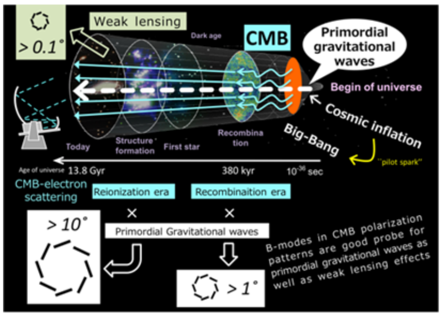


Figure 1 B-modes are probes of the primordial gravitational waves and weak lensing effect.

## 【Research Methods】

We will develop one of the SO telescopes, and conduct scientific observation in the international collaboration. In order to successfully perform large angular scale observations of the CMB polarization, we must simultaneously achieve high mitigation of atmospheric fluctuation effects, high sensitivity, and high statistics. The combination of Japan and USA technologies, e.g. superconducting detectors and patent cooling technologies, will be the key for success of the project. In FY2017, we plan to fix specifications of our telescope. We will then continue the development our instruments and target to start observations in FY2020. We will evaluate the performance of our experiment based on the initial data set and will confirm our scientific prospects.

## 【Expected Research Achievements and Scientific Significance】

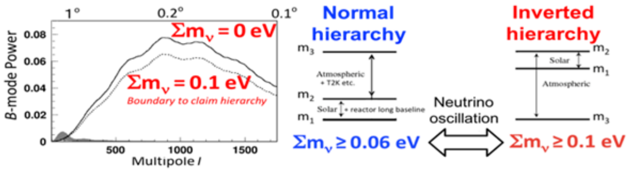


Figure 2 Measurements of $\Sigma m_\nu$ potentially determine mass hierarchy of neutrino.

The world's largest CMB telescope array will produce the most precise CMB polarization data to date. This measurement can potentially prove cosmic inflation which provides explanations to unsolved subjects in cosmology, e.g. the flatness of the universe, the horizon problem, and the absence of the monopole. Detection of PWG via B-mode observations can show that the energy scale of the inflationary potential corresponds to the energy scale of the grand unified theory in the particle physics at $10^{16}$ GeV. Moreover, the existence of PWG is evidence for the quantization of gravity in the early stage of the universe. Measurements of $\Sigma m_\nu$ potentially determine the mass hierarchy of neutrinos.

## 【Publications Relevant to the Project】

QUIET Collaboration, ApJ, **760**, 145, 1 – 10 (2013).

POLARBEAR Collaboration, ApJ, **794**, 2, 171 – 191 (2014).

**【Term of Project】** FY2017-2021

**【Budget Allocation】** 161,100 Thousand Yen

**【Homepage Address and Other Contact Information】** https://simonsobservatory.org/