Newsletter Focus

QUBIC: A NEW WAY OF STUDYING THE PRIMORDIAL UNIVERSE



On 21 April, eight articles were published in a special edition of the *Journal of Cosmology and Astroparticle Physics* authored by the international collaboration QUBIC (Q&U Bolometric Interferometer for Cosmology). QUBIC is creating a telescope in Argentina for studying the newborn universe that will make use of an innovative technique. QUBIC, in fact, will observe and map the properties of the cosmic microwave background,

the residual echo of the Big Bang, concentrating on measuring particular components of the orientation of fluctuations in cosmic microwave background radiation on the plane of the sky (polarisation), called B-modes, which are indicative of the possible perturbations induced by gravitational waves generated in the first instants of the life of the universe. The project involves Italy as leader thanks to its scientific and technological contributions provided by INFN and by the Universities of Milan and Milano-Bicocca, the Tor Vergata University of Rome, and Sapienza University of Rome. QUBIC will observe the sky beginning from the end of 2022 from a high-altitude desert site (5,000 m) in Argentina, close to the town of San Antonio de Los Cobres. After its development and integration, which occurred at European laboratories of the universities and research bodies involved in the collaboration, QUBIC arrived in Argentina, in the city of Salta, in July 2021, where the final stages of calibration and laboratory testing are underway. The results of these activities have confirmed the correct operation of the instrument and the bolometric interferometry, which combines the extreme sensitivity of the detectors - cooled almost to absolute zero (-273 °C) and able to measure the energy of the cosmic background radiation by transforming it into heat (bolometers) - with the precision of interferometry tools. Thanks to its extreme sensitivity, which makes it possible to distinguish the details of each of the 'pixels' in which the celestial map will be divided, QUBIC will be able to identify B-modes generated by the other sources of the sky, providing direct proof of the Inflation Theory.

According to the Inflation Theory, the very fast expansion of the universe immediately after the Big Bang, which lasted less than one hundred-thousandth of a billionth of a billionth of a billionth of a second (approximately 10⁻³² seconds), would have left a weak background of gravitational waves that, in turn, would have produced special, very weak traces, called B-modes, in the polarisation of the cosmic microwave background. In practice, the electromagnetic waves of the cosmic background would not oscillate in random directions. They would, instead, slightly prefer directions that form a swirling pattern in the sky.

The search for B-modes is a formidable challenge and central for physicists and astrophysicists. The signal to

be measured is so weak that it requires ultra-sensitive detectors and high-precision telescopes, needed also to remove other polarised signals of local origin, during the data analysis, which could confuse the measurement. The QUBIC measurements will, therefore, be contemporaneous to those of half a dozen of other experiments in the world that have the same scientific goal. In contrast to these, which directly produce images via single-aperture telescopes, QUBIC will be the only tool to make observations by gathering microwaves from many apertures and making them interfere.

The precision of the measurements that QUBIC makes will also be aided by the clarity and absence of humidity that distinguish the air of the Alto Chorrillo site where the telescope will be installed, approximately 5,000 metres above sea level on the La Puna plateau in northern Argentina, near the town of San Antonio de los Cobres, in the province of Salta.

For more information:

QUBIC website: http://qubic.in2p3.fr/wordpress/ (http://qubic.in2p3.fr/wordpress/) Special edition of JCAP (https://iopscience.iop.org/journal/1475-7516) (Journal of Cosmology and Astroparticle Physics): https://iopscience.iop.org/journal/1475-7516/page/Special%20Issues (https://iopscience.iop.org/journal/1475-7516/page/Special%20Issues)

* QUBIC is the result of the collaboration of 130 researchers, engineers, and technicians in France, Italy, Argentina, Ireland, and the UK. The instrument, which was integrated in Paris at the APC laboratories in 2018 and calibrated during 2019-2021, is housed in a cryostat, designed and constructed in the laboratories of the Sapienza university and of the INFN Rome Division. The same group also created the cryomechanical system that rotates the optical components inside the cryostat to measure the state of polarisation of the radiation. Other cryogenic components, which operate at a temperature below -270 °C, are also Italian, like the highly advanced corrugated antennas that select the photons to be interfered, produced in the laboratories of the University of Milan and the INFN Milan Division. The optics that focus the photons on the detectors and the shutter system that varies the configuration of the interferometer and its self-calibration were produced by the University and INFN Division of Milano-Bicocca. The Tor Vergata University of Rome and the INFN Roma 2 Division are contributing to the development of the complex software for data analysis.