

Building a prototype large-aperture telescope for CMB polarization measurements

J.A. Rubiño, on behalf of the QUIJOTE collaboration. March 2018.

Context

QUIJOTE comprises two 2.5-m, fully spinning, off-axis telescopes with the Crossed-Dragone optical design, to measure CMB polarization at 10-40 GHz. The first QUIJOTE telescope QT-1 is in operations since November 2012, and the second one was installed in 2014. Both telescopes were specified by the IAC QUIJOTE team and built by the IDOM company in Spain. The QUIJOTE experiment has been designed to reach the required sensitivity to detect a primordial gravitational wave component in the CMB, provided its tensor-to-scalar ratio is $r=0.05$. Such component would leave its imprint on the polarization angular power spectrum of the CMB, producing the so-called "B-modes". The detection of primordial B-modes with that amplitude would open new paths into the physics of the epoch of inflation.

Together with QUIJOTE, the Teide Observatory will have in the next year two new microwave/sub-millimeter experiments: GroundBird and LSPE-STRIP. Taken all together, this set of experiments will consolidate the Teide as a reference observatory for CMB studies in Europe, covering an extremely broad and unique range of frequencies, from 10 to 280 GHz.

Plans for future CMB observations

Nowadays, we are discussing at European level what should be the next steps in CMB research in the next decade. The preliminary version of the roadmap (in preparation) considers the construction of 6-m class telescopes, scaling the cross-Dragone concept of QUIJOTE, in order to conduct in the future high sensitivity surveys of the radio emission at low frequencies, reaching resolutions of 20 arcmin around 15 GHz. This resolution will allow us to map the radio foregrounds at the required angular resolution to correct them down to the recombination bump of the primordial B-mode signal. See <https://wiki.e-cmb.org/>. The primary motivation for keeping the cross-Dragone design is its high optical throughput and the low levels of polarization systematics, in comparison to other existing large-aperture CMB telescopes.

In US, the CMB-S4 plan (<https://cmb-s4.org/>) considers also the fabrication of several large-aperture telescopes (also 6-m class) for the next decade. Indeed, a 6-m aperture cross-Dragone design has recently been adopted by both the CCAT-prime (http://www.ccatobservatory.org/index.cfm/page/observatory/telescope_details.htm) and Simons Observatory collaborations (<https://simonsobservatory.org/news.php>).

Proposal

Based on the current optical design of the QUIJOTE telescopes, we propose to build a prototype large-aperture telescope optimized for CMB polarization measurements. The global requirements are:

- Optical design based on QUIJOTE telescopes (cross-Dragone). Optical quality specified to operate up to 250GHz, similar to the QUIJOTE optics.
- Adapt the new telescope to operations in open air. Currently, QUIJOTE telescopes are protected by a dome.
- Study the scalability of the concept and develop a prototype of at least 3-m class (i.e. a new version of QUIJOTE), and if possible, build directly a 6-m class telescope (final goal).

- Flexible design of the focal plane station, in such a way that instruments can be easily interchanged.
- Telescope will be tested with the existing instrumentation in the project, or instruments under development.

Impact

The IAC QUIJOTE group have wide experience in specifying these CMB telescopes, including optics, mechanics, electronic and software requirements, as well as the integration of the telescopes in the observatory. In addition, the instrumentation operating in the QUIJOTE telescopes has been developed and integrated at the IAC in all its phases, from the requirements to the operation.

From the scientific point of view, this new infrastructure will put the Teide Observatory as a reference location (ICTS) in the northern hemisphere for CMB research for the next decade, consolidating its current status.

It will also provide the opportunity to the Spanish industry of establishing a very competitive position in the development of this type of infrastructures, which will be needed in the next decade.

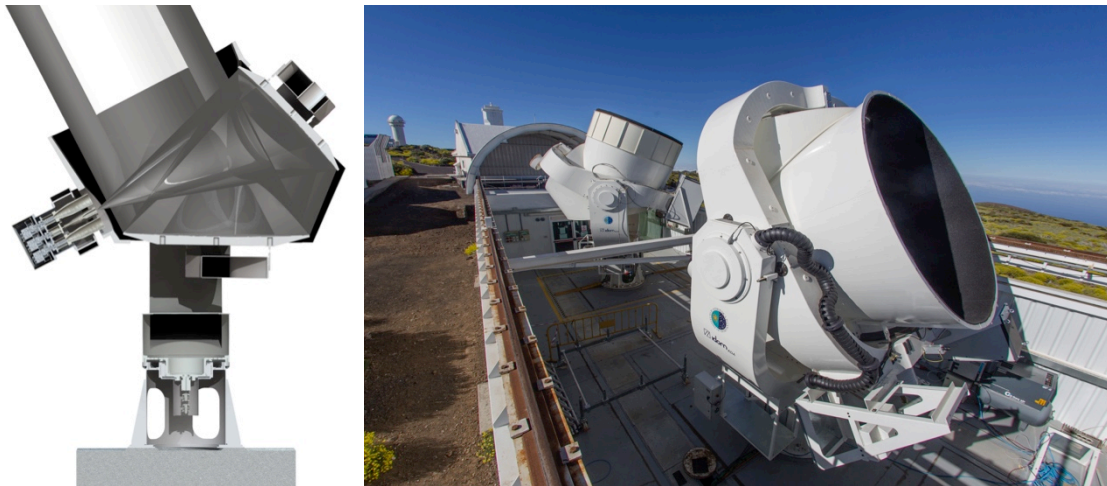


Figure 1. Left: optical design of a QUIJOTE telescope. Right: Two QUIJOTE telescopes at the Teide Observatory.

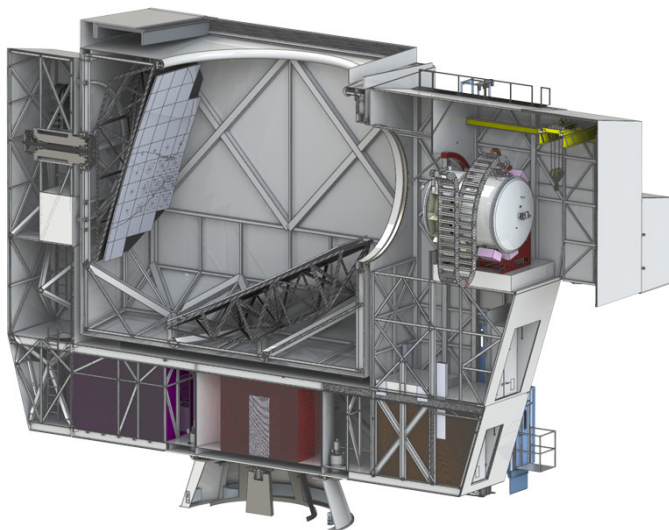


Figure 2. Rendering of the Simons Observatory Large Aperture Telescope (LAT). Views towards section of the LAT. Taken from <https://simonsobservatory.org/news.php>