





LiteBIRD

Lite satellite for B-modes from Inflation CMB Radiation Detection

G. Morgante (OAS Bologna) on behalf of the LB Team

RSN1 Audit, May 24th 2021



LiteBIRD in a nutshell



- Selected (May 2019) as the next JAXA's strategic L-class mission (#2) with an expected launch in 2028 (TBC) with JAXA H3 rocket
- Observations for 3 years (baseline) around Sun-Earth Lagrangian point L2
- Mission δr (total uncertainty) < 0.001 (for r=0) with CMB B-mode observation</p>
- □ Two telescopes: Low (LFT) and Middle + High Frequency (MHFT) Telescope
- Millimeter-wave all sky surveys, 15 bands 34–448
 GHz at 70–20 arcmin
- □ Complex cryochain: semi-passive + PT/ST/JT/ADR
- TES focal planes @ 100 mK
- □ LiteBIRD is the only CMB space mission in the 2020s timeframe





Activities: international organization



~300 scientists worldwide

Interim Governance Board (PI, PS, JSG Conveners etc.)

Editorial and Membership boards

Joint Study Groups (JSG)

PLM Design	Systematic Uncertainties	Foreground cleaning	Calibration strategies
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Joint Study sub-Groups

Cross-JSG	Readout Electronics	Data Management	Simulations	MHFT
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LB science products activity → Project Study Papers:



Cosmic Birefringence

J. Errard (APC)

• A. Gruppuso (INAF-OAS)

Optical Depth, Reionization of the Universe, and Neutrino Masses

- M. Lattanzi (UniFe)
- M. Tristram (LaL)

Gravitational Lensing of the CMB

T. Namikawa (UniStanford)

*Cross-correlation Science*M. Migliaccio (UniRM2)

Isotropy & Statistics: A view on CMB anomaliesT. Banday (IRAP)

Mapping the Hot Gas in the Universe

- G. Luzzi (ASI-SSDC)
- M. Remazeilles (UniManchester)

Galactic Science (Coordination GS WG):

The 3D Milky Way (Lead TBC)

Galactic Astrophysics (Lead TBC)



European Consortium



- The European collaboration is responsible for the development of the MHFT and consists of 9 partners: France, Italy, Spain, United Kingdom, Germany, Sweden, Norway, Ireland, the Netherlands, with a total of more than 100 members to date
- European activities are coordinated by a Steering Committee led by a Spoke-person and composed by the representatives of all partners
 - Italy is represented by two members and has the present Chair of the SC
- □ MHFT design and development:
 - Led by CNES with a PM (since Feb 2020)
 - MFHT Project Office, the structure that will develop the telescope, detailed structure still under discussion
- □ The italian participation includes:
 - INAF, INFN, SISSA, UniFe, UniMi, UniMiB, UniPD, UniPi, UniRM1 e UniRM2





INAF Contribution



□ The INAF responsibilities on LB are based on the Planck and Euclid heritage

- The teams at OAS and OATs have been building over the leading roles played in Planck in the last two decades and are fully qualified and ready for the challenges of an ambitious mission like LiteBIRD, in the following research lines:
 - CMB cosmology (Inflation, Cosmic Birefringence, Magnetic Fields)
 - CMB data handling/analysis/storage
 - Design, test and calibration of space instrumentation at cryo T



LiteBIRD – Science Perspectives



The main target of LiteBIRD is the measurement of CMB B-mode polarization from inflationary gravitational waves with unprecedented accuracy. The LiteBIRD sensitivity will allow a cosmic variance measurement of CMB E-mode polarization which is of utmost importance for reionization and for testing the fundamental physics nature of the anomalies on large angular scales found in the WMAP and Planck temperature maps.



Primordial B-mode Polarization

The faint signal of B-mode polarization is the footprint of primordial gravitational waves from inflation (the theory which explains the quantum origin of the cosmic structures) or of exotic physics as cosmic birefringence or primordial magnetic fields. Its measurement would have strong implications for fundamental physics and still open questions in cosmology. The great sensitivity, full sky and wide frequency coverage, permitted by being in space, will allow to remove/mitigate the astrophysical contamination and measure the large scale B-mode polarization to a level not accessible from the ground.

The LiteBIRD E-mode polarization measurement will complement ground based CMB experiments in a strong reduction of the uncertainties in cosmological parameters

Reionization: The accuracy of LiteBIRD measurements will allow to constrain the reionization history tightening the constraints on extended cosmological models, e.g. neutrino physics.

Anomalies: Large scale anomalies such as the lack of power, features, even-odd asymmetry, hemispherical power asymmetry etc. may be the traces of non-standard inflationary models, pre-inflationary phases or even alternatives to inflation.



LiteBIRD Mission – RSN1 Audit, May 24th 2021



Highlights



Inflation: LiteBIRD will determine with great accuracy if the energy scale of inflation is the typical GUT (Grand Unified Theory) energy scale (i.e. 10^16 GeV, 12 orders of magnitude greater than the one within particle accelerators) and its sensitivity on the tensor-to-scalar ratio r will reach delta r = 0.001, improving by a factor 30 over current limits.

F. Finelli co-leader of the dedicated paper project team



Cosmic Birefringence: Violations of standard physics in the early Universe as in the electromagnetic interaction can rise a cosmic birefringence effect. LiteBIRD will be able to detect a birefringence effect signature in B-mode polarization.

A. Gruppuso co-leader of the dedicated paper project team



D. Paoletti leader of the dedicated paper project team







The LiteBird SGS Proposal



- Building on the expertise based on the implementation of the Planck and Euclid SGS, a specific WP in the ASI contract is dedicated to build a HW/SW infrastructure for the Italian CMB community to test and use the algorithms for the simulations and data analysis of future CMB space experiments
- The aim here is to lay down the basic design of the LiteBIRD Science Ground Segment
- A first structure is shown in the figure: the structure and a preliminary version of the Management Plan is being discussed within the LB collaboration





INAF HW contribution (@OAS)



The Italian HW contribution is dedicated to the implementation of the polarized modulator of the MHFT and other optical units (UniRM1), the control/readout electronics (INFN), an important contribution to the calibration and AIV activities of the MFHT (UniMi and INAF OAS)

□ Lab activities @ INAF-OAS

- Characterization of thermal/RF properties at cryogenic T of materials & units at prototype/EM level
- One of our cryofacilities at the Cryowaves Lab being upgraded with a new RF Spectroscopic System to measure the *scalar* RF properties at low T (< 5K)

□ Calibration/AIV activities @ INAF-OAS

- Participate to the telescope EM calibration and AIV activities at sub-system and system level
 - G. Morgante proposed (TBC) as the coordinator of the 4K cryo test of MHFT ORFEM
- The final goal is to play an important role in support/contribute to the on-ground and flight calibration activities of the MHFT system and of the overall LiteBIRD payload



INAF Team & Leadership



#	Nome	Struttura	TI	Ruolo & Leadership
1	Francesco Cuttaia	OAS Bologna	Υ	RF Engineer
2	Fabio Finelli	OAS Bologna	Y	Manager of ASI WP 3-6X32 - "Forecasts for new space missions"
				LB Project Paper Study "Inflation"- co-Lead
3	Marco Frailis	OA Trieste	Υ	Software Engineer
4	Samuele Galeotta	OA Trieste	Υ	Software Engineer
5	Alessandro Gruppuso	OAS Bologna	Y	Manager of ASI WP 3-6X22 - "Non-standard signatures from CMB polarization"
				LB Project Paper Study "Cosmic Birefringence" - co-Lead
6	Michele Maris	OA Trieste	Υ	Collaborator
7	Gianluca Morgante*	OAS Bologna	a Y	Manager of ASI WP 5-6X22 - "Cryogenic testing"
				MHFT PO Calibration WP "4K RF Test at EM", co-Lead (TBC)
8	Daniela Paoletti	OAS Bologna	Ν	Manager of ASI WP 4-6X53 - "Parameter estimations"
				LB Project Paper Study "Magnetic Fields" - Lead
9	Maura Sandri	OAS Bologna	Υ	Optical Engineer
10	Daniele Tavagnacco	OA Trieste	Υ	Manager of ASI WP 4-6X11 - "Science Ground Segment"
11	Luca Terenzi	OAS Bologna	Υ	Thermal Engineer
12	Fabrizio Villa	OAS Bologna	Υ	Optical Engineer
13	Andrea Zacchei	OA Trieste	Υ	Manager of ASI Node 4-6X1 - "Science Ground Segment"

* ASI contract responsible for INAF

The INAF participation to LB for the next 3 years counts a total of 11 FTE plus the relevant contribution of 12 INAF Associates from CINECA, SISSA, UniBo, UniFe, UniMi/UniMiB, UniPD, UniRM1, UniRM2 (see details in the online form)



Project Schedule





□ At present the project is in Phase A2 of JAXA, with the European activities in Phase A

- Sync the European MHFT activities schedule with the JAXA (and other partners) is not trivial
- The high-level schedule of the LiteBIRD mission is still under revision due to issue with some international partners (NASA)

The ASI Phase A contract (2020-2023) schedule follows a standard milestone approach:

a) KOM on 12.05.2020; b) First Progress Meeting (RA1) on 19.03.2021; c) Second PM (RA2) expected for October 2021; d) Third PM (RA3) within 30 months from KOM; e) Final Meeting (RF), within 36 months from KOM



Project Funding



□ JAXA flagship science L-mission with HIIA/H3 vector \rightarrow cost-cap of 30B yen = 300M USD

□ At this stage, there is no ESA MoO support

- The European contribution is supported by the national agencies of the member countries
- The Italian scientific/technological contribution is supported by ASI and INFN
- ESA is anyway constantly monitoring the development of the MHFT
- ASI commitment should grant support for the full development of the mission with the usual Project Phase sync contracts
- ASI contract for Phase A:
 - 36 months, 2M€ total ASI funding (wrt a 5M€ total envelope), 329k€ for INAF (OAS & OATs)
- \Box Phase A activities = study/preliminary design \rightarrow HW/Tech funding are limited
 - Personnel expenses are our priority
 - Limited resources for the experimental activities are a constraint to a possible higher HW contribution (Phase A is critical in this sense)



Criticalities



□ INAF CMB cosmology team consolidation/reinforcement

- TI position opportunities in the (near) future
- Encourage the participation of enthusiastic resources like PhD students, post-doc (fellowships)

□ Big data handling/storage has been an increasing need for projects

 This can be managed only partially at local level: needs coordination at INAF/national level to get regular/easier access to high computing facilities (e.g. CINECA) or to verify the possibility of a centralized computing facility

Cutting-edge HW technology requires expensive lab upgrade, maintenance and specialized expertise

- Chronical shortage of funding (1), specialized expertise (2), manpower (3) for Lab activities
 - 1) Phase A funding for HW/Tech activities is limited
 - 2) Shortage of specialized mech/thermal/electrical/optical engineers with "System Eng" approach
 - 3) Encourage the participation of enthusiastic resources like students, PhD and post-doc to *experimental activities* (increase synergies of the labs with University deps like Astronomy, Physics, Engineering, Computer science etc.)