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MARCO BERSANELLI
CURRICULUM VITAE

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Current position:

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Research profile

Professor Marco Bersanelli (M.B.) works in the field of observational cosmology, particularly on measurements of the Cosmic Microwave Background (CMB), the relic radiation from the early universe. In the past 26 years he has been playing a leading role in the ESA Planck space mission, launched in 2009, dedicated to high-precision, high-resolution, full-sky measurements of the CMB in temperature and polarization.

Since the beginning of the Planck project (1992, initially called COBRAS/SAMBA), M.B. contributed to the definition of the scientific goals, payload and satellite configuration, orbit and scanning strategy. M.B. has been the Instrument Scientist and Deputy-PI of Planck Low Frequency Instrument (LFI) – one of the two instruments on-board the satellite – and a member of the Planck Science Team. He led the design, development, testing and calibration of the LFI, an array of cryogenic coherent HEMT-based radiometers in the 30-70 GHz range cooled to 20K. He led an international Instrument Team through all phases of integration and testing (QM and FM): unit level and prototyping (before 2003), Instrument Level Test (Thales-Milano, 2005-06), Satellite Level Tests (CSL, Liege 2007-09). After launch (Kourou, ESA Spaceport, 12 May 2009) the Planck spacecraft carried out four years of uninterrupted observations from a Sun-Earth L2 orbit. The LFI instrument was 100% functional and fully met its scientific goals. M.B. also contributed to the Planck data analysis, including calibration of the frequency maps, analysis of systematic effects, LFI-HFI inter-calibration.

The Planck results, released in 2013, 2015 and 2018, provided a spectacular confirmation of the Λ CDM cosmological model and led to high precision estimates of the key cosmological parameters (baryon density, dark matter density, Hubble constant, curvature, limits on neutrino mass, dark energy) as well as new stringent limits on inflation scenarios. The Planck data also yielded unprecedented results in Galactic and extragalactic astrophysics, including the first full-sky survey of galaxy clusters via the SZ effect, the discovery of thousands of new point sources, and new studies of interstellar dust emission, synchrotron radiation, magnetic fields in the Milky Way. As

an outcome of his contribution to Planck, M.B. has co-authored over 140 refereed papers with more than 27,000 citations.

Before the onset of the Planck project, M.B. worked at LBNL, University of California at Berkeley, in the group of G.F. Smoot (Nobel Prize for Physics in 2006). In the period 1986-93 M.B. carried out a series of ground-based observations to measure the frequency spectrum of the CMB in the range 1.5-90 GHz. He participated in three field campaigns at the White Mountain High-Altitude Station, University of California, and in two campaigns at the Amundsen-Scott Station at the South Pole. M.B. led the instrument development, operation and data analysis of two instruments operating at 2.0 and 90 GHz. These efforts produced new limits to CMB spectral distortions at low frequencies before the COBE/FIRAS data became available. M.B. also used the South Pole and White Mountain data to study the diffuse synchrotron and free-free emission from the Milky Way and the microwave properties of the Earth's atmosphere. In parallel, in the 1990's, M.B. participated in a study of the Optical and Near-IR properties of Active Galactic Nuclei (AGNs), in particular BL-Lac objects, based on observations at ESO, La Silla, Chile and San Pedro Martir Observatory (Mexico).

M.B. promoted several mm-wave technology development projects, involving Industry, Research Institutes and Universities. In the years 2010-14 he led a large National mm-wave technology project, funded by ASI, which involved Thales Alenia Space Italy as prime contractor, other Italian companies, and essentially all the research groups working on CMB instrumentation in Italy. In the early 2000's he founded the Microwave Laboratory at Physics Department, University of Milano, devoted to precision characterization of microwave subsystems, as well as to training of students and young researchers. The lab, currently led by one of his former students, covers development of microwave components, precision characterization of CMB instruments and is open to collaboration with industry and commercial enterprises.

Currently M.B. is engaged in new efforts to push CMB research beyond the current state of the art, particularly through the search for signatures from primordial gravitational waves in the CMB polarization pattern ("B-modes"). He is PI of STRIP, a ground-based CMB telescope to be operated in Q and W band, in combination with balloon-borne measurements at higher frequencies (ASI/INFN-funded LSPE programme). M.B. and his group are also involved in the QUBIC experiment, based on bolometric interferometry, in which M.B. is an *Instrument Architect*. Both STRIP and QUBIC are planned to be installed in 2022 in high-altitude sites, i.e., respectively, at the Teide Observatory (2500m), Canary Islands, and at Lloma (5000m), in the Argentinian Andes. M.B. and his group are also contributing to the COSMO experiment, designed to probe CMB spectral distortions with measurements from Dome C, Antarctica.

Since the early 2010's, while still fully engaged in Planck, M.B. has contributed to feasibility studies for a next-generation satellite devoted to CMB polarization in the ESA context (CORe, PRISM, COReplus). Since 2018, M.B. has been active in the JAXA-led LiteBIRD space project. He is currently part of the LiteBIRD high-level governance committee (Interim Governance Board, IGB), co-lead of the pro-tempore Publication Board, and leader of the ASI contribution to LiteBIRD calibration, in particular for the Europe-led Medium-High Frequency Telescope (MHFT) covering the 100-400 GHz frequency range. In 2018-2020 M.B. and his group played a key role in *BeyondPlanck*, a EU-funded H2020 COMPET project designed to develop a novel approach to CMB data analysis, that was successfully applied to the Planck-LFI data.

Academic career

1986: Graduation in Physics, University of Milano;
1986-90: Visiting Scholar at Lawrence Berkeley National Laboratory, University of California, Berkeley;
1988-99: Staff Researcher at *Istituto di Fisica Cosmica e Tecnologie Relative (IFCTR)*, CNR, Milano;
1999-00: Senior Researcher at *IFCTR*, CNR, Milano;
1990-95: Visiting Researcher at Lawrence Berkeley National Laboratory;
2000-06: Associate Professor of Experimental Physics, Physics Department, University of Milano;
2000-present: Associate of *Istituto Nazionale Astrofisica*, INAF
2006-present: Full Professor of Astronomy and Astrophysics, Physics Department, University of Milano.
2016-present: Associate of *Istituto Nazionale di Fisica Nucleare*, INFN

Scientific and managerial responsibilities

1993-94: Assessment Study of COBRAS/SAMBA mission (ESA);
1994-96: Phase A Study of COBRAS/SAMBA mission (ESA);
1996-2018: Science Team of the Planck mission (ESA), Instrument Scientist of Planck-LFI;
2010-2018: Deputy PI of Planck-LFI;
2005-07: Science Committee of *Istituto Nazionale di Astrofisica* (INAF);
2003-2013: Vice-President of *Consorzio Inter-Universitario di Fisica Spaziale* (CIFS);
2003-present: Science Director of *Euresis* (Association for the Promotion of Scientific Culture);
2005-present: *Piero Caldirola International Center for the Promotion of Science and International School of Plasma Physics*;
2009-present: Science Committee of *Camplus*, Excellence University Colleges Network;
2009-2015: Director of the *PhD School in Physics, Astrophysics and Applied Physics*, University of Milano;
2010-2011: Search Committee for the Directorate of the *National Agency for the Evaluation of Universities and Research Institutes* (ANVUR);
2011-2014: Member of the National Scientific Committee for Research in Antarctica (CSNA);
2011-2015: Scientific Advisor of the Italian Delegation at the Science Program Committee (SPC) of ESA as representative of INAF;
2012-present: Co-PI of LSPE and PI of the LSPE/STRIP instrument;
2014-present: Advanced ERC Panel PE9 – Universe Sciences;
2015-present: Representative of Italy (with C. Baccigalupi) in the European CMB (*E-CMB*) Coordination Committee;
2016-present: Scientific Committee of *Planetario di Milano*;
2016-present: *Architect* in the QUBIC Collaboration;
2017-present: *Co-Convener* of the Calibration WG for LiteBIRD and *Joint Study Groups (JSG's)* on Calibration and Systematic Effects.
2019-present: IGB member in the JAXA-led LiteBIRD space project.
2019: Management Review of the Euclid ESA space mission.

M.B. participated in a number of scientific and technical evaluation committees (for ASI; NASA; *Agence Nationale de la Recherche*, France; Irish Government; Spanish Government, JSPS, Japan; CONICYT, Chile) and in hiring of highly specialized personnel at international level. Since 2014 he

has been a member of the Advanced European Research Council (ERC) on Universe Sciences (PE9). He has served as reviewer for hiring professors and tenure track researchers in several European Countries, USA, and Japan. In Italy, he regularly takes part in committees for evaluating National Grants (PRIN, SIR, FIRB) and for hiring University professors and research staff. In 2010 he was nominated by the Italian Ministry in the ANVUR Search Committee. In 2019 he was co-coordinator of the Italian National Research Plan (PNR) for the “Space” sector.

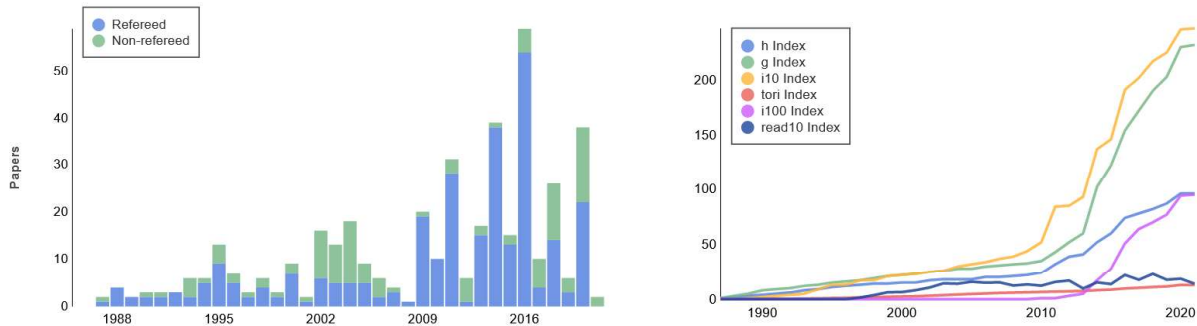
As Director of the PhD School in Physics at Milano University, in the period 2009-2015, M.B. has managed a PhD program for 125 PhD students and led a Graduate Faculty Committee of about 65 professors covering all areas of Physics, including Astrophysics and Cosmology, Particle and Nuclear Physics, Matter Physics, Theoretical Physics, Applied Physics.

M.B. has been PI or co-PI of a number of science and technology grants. Italian ministerial (MIUR) grants included: PRIN (2006-2008), 150k€; PRIN (2009-2012), 269k€. ASI and INFN funded projects (besides Planck-LFI) included: PI of Millimeter-Wave Technology Development (ASI contract N. I/038/09/0, 2010-2014), 3M€; PI of LSPE/STRIP (2012-present), about 2.5M€. Co-PI in Regional Council (Sardinia and Lombardy) funded program on Microwave Technology Development (2012-2016), total budget: 3.2 M€. He is one of the two Italian representatives in the European-CMB (E-CMB) Coordination Committee, and Co-I in the ASI-supported COMSOS project to support CMB research in Italy (PI N. Vittorio).

Throughout his career M.B. has gained significant experience in the management of large scientific projects and familiarity with the Italian, European and International space communities. His 26-year full-dedication and leading role in Planck (involving over 400 scientists) provided him a unique opportunity to collaborate not only with scientific teams, but also with Industry, engineers and managers. His international profile led him to a number of lasting partnerships with groups worldwide, particularly in USA, Spain, UK, France, Germany, Finland, Norway, Canada, and more recently Japan. The challenging and successful development of Planck was carried out within the ASI and ESA management and in close collaboration with Italian and European Industry. As Instrument Scientist and Deputy-PI of Planck/LFI, M.B. has been directly and continuously exposed to these components of the space enterprise. His has matured interest in space technology and motivation to share scientific driven results with industrial partners.

Publications, Conferences

M.B. is author of 418 papers in the field of Astrophysics and Cosmology (publication rate: see plot below, *left*), 299 of which are published in astrophysics Refereed Journals (*Astronomy & Astrophysics, The Astrophysical Journal, The Astronomical Journal, JCAP, Monthly Notices of the Royal Astron. Soc., Astrophysical Letters & Comm.*) and technology-related Refereed Journals (*IEEE, Experimental Astronomy, JINST*). H-index: 96; Citations: over 54,500 (for details see plots below – Source: NASA/ADS, update: 24 Jan 2021). M.B. is author of many *Conference Proceedings* and *Technical Reports*, some of which were key for the development of hardware for the Planck mission. He was Guest Editor of the *JINST* Special Issue dedicated to the Planck-LFI instrument.



M.B. routinely serves as referee in many international specialized Journals of astronomy, astrophysics and related technologies. Since 2013 he is Editor of Journal of Instrumentation (JINST). Since 2020 he is Reviewing Editor for Physics and Astronomy for *Experimental Results*, Cambridge University Press.

In the past 10 years M.B. gave over 35 invited talks and lectures, mostly presenting Planck results or cosmology reviews, in several Universities and Research Centres, including (*selection*): Heidelberg University (30 May 2008); Copenhagen Niels Bohr Institute (9 Jun 2009); ESA/ESTEC (27 Oct 2008, 4 Apr 2013); Varenna/IDAPP (17 Jun 2009); Barcelona University (10 Sep 2010); Pars/IAP (10 Jan 2011, 25 Jun 2012); Padua/INFN (18 May 2011); Chicago, Fermilab (7 Mar 2012); South Dakota/PPC2013 (12 Jul 2013); Como/ICATPP (23 Sep 2013); Pavia University (25 Sep 2014, 23 Jun 2016); Ferrara University (1 Dec 2014); University of Milano-Bicocca (12 Dec 2014); Catania/SAIT (18 May 2015); Princeton University/CMB50 (Jun 2015); Rome La Sapienza/MGXIV (Jul 2015); Moscow, Lomonosov University, 25 Sep 2015; University of Köln, 20 Oct 2015; Milano Politecnico (11 Apr 2016); Turin Observatory (27 Apr 2016); CERN, Geneva (18 May 2016); James Madison University, USA (1 Nov 2016); Paris LiteBIRD Workshop, (23 Oct 2017); ESAC, Madrid (4 Dec 2018); Roma, Euclid and Beyond (11 Feb 2019); Naples, INAF national Meeting (27 Mar 2019); Tokyo, LiteBIRD Kick-off Meeting (1 Jul 2019).

M.B. has co-organized several international Conferences and has been member of the Science Organizing Committee (SOC) of (*selection within the past 10 years*): Como, 8-16 July 2009 – International School of AstroParticle Physics, European Doctorate School *CMB and Fundamental Interaction Physics*; Paris, Cité des Sciences 10-14 January 2011 – *The millimeter and submillimeter sky in the PLANCK mission era*; São José dos Campos, Brazil, 12-16 September 2011 – IV INPE Advanced School on Astrophysics, *Radio Astronomy for the 21st Century*; Bologna, Italy, 13-17 February 2012 – *Astrophysics from the Radio to the Submillimetre: Planck and other Experiments in Temperature and Polarization*; Paris, France, Université Paris 7, APC, 11-12 December 2012 – *Microwave Spectral Polarimetry*; Pula, Italy 11-16 June 2012 – *Detecting Cosmic Radio Waves: Technology in Radio Astronomy and Space Science* (co-Chair and Lecturer); Noordwijk, The Netherlands, ESA/ESTEC, 2-5 April 2013 – 47th ESLAB Symposium: *The Universe as seen by Planck*; L'Aquila, Italy, 22-26 April 2014. International School of Space Science on *Observing the Universe with the Cosmic Microwave Background* (Co-Director and Lecturer); Ferrara, 1-5 December 2014 – *Planck 2014: the microwave sky in temperature and polarization*; Tenerife, 22-26 June 2015 – EWASS Session *The quest for detecting the primordial gravitational wave background*; Honolulu, 11-13 August 2015, IAU GA Meeting, *The legacy of Planck*; Florence, Villa Finaly, APPEC-ASTRONET - Meeting Series *Towards the European Coordination of the CMB programme*: 8-10 September 2016; 6-7 September 2017; 20-21 September 2018; Rome, University La Sapienza, 1-7 July 2018, 15th Marcel Grossmann, Session *CMB observations*.

Impact of the first Planck results, published in 2013:

- Science News: "Planck refines cosmic history" as #3 in its Science News Top Stories of 2013, Featured in Cover of the 28 December issue;
- Nature: Planck appeared near the top of Nature's article: "365 days: 2013 in review";
- Physics World: Planck results were named one of the 10 Breakthroughs of the Year 2013
- BBC: The Planck CMB map is among the BBC's "Best Space Images of 2013"
- Le Scienze: Planck as the most important news of the year 2013

Honours and Prizes

1990: NATO Advanced Grant;
 1991: NSF Medal for Research in Antarctica;
 2007: FEST (*Fiera Internazionale Editoria Scientifica*), Trieste;
 2009: ASI recognition of outstanding contribution to the Planck mission
 2010: ASI Award for contribution to Planck (*with N. Mandolesi and C. Butler*);
 2010: ESA Award for achievements in Planck (*with Planck Collaboration*);
 2010 Grand Prix Spécial of the Astronautical and Aeronautical Association of France (*With Planck and Herschel teams*)
 2012: Istituto Lombardo Accademia di Scienze e Lettere;
 2014: NERSC Award for High Impact Scientific Achievement (*with Planck Collaboration*);
 2018: Group Achievement Award from the Royal Astronomical Society (*with Planck Collaboration*);
 2018: Gruber Prize for Cosmology (*with Planck Team and PI's*)
 2018: Grossmann Prize (*with Planck Team*)
 2019: European Physical Society, Giuseppe and Vanna Cocconi Prize (*with Planck and WMAP Teams*)

Teaching and Research Training

1986-87, University of California, Berkeley: *Teaching Assistant, Course 7C (Physics for Engineers)*;
 1996-99, S.I.S.S.A., Trieste: *Observational tests in Cosmology, graduate course*;
 1999-01, University of Milano: *Physics for Computer Science; Laurea in Computer science*;
 2000-06, University of Milano: *Laboratory of Space Instrumentation, Laurea Magistrale in Physics*;
 2003-05, University of Milano: *Introduction to Astrophysics, Laurea Triennale in Physics*;
 2004-06, University of Milano: *Cosmologia, Laurea Magistrale in Physics*;
 2006-present, University of Milano: *Astronomy (Part I and Part II), Laurea Magistrale in Physics*;
 2009-present, University of Milano: *Physics 1 (Mechanics) Laurea Triennale in Physics*.
 2017-present, Graduate School, University of Milano: *Advanced topics in Astrophysics and Plasma Physics, Observations of the Cosmic Microwave Background*

M.B. has been Supervisor/Referee of 16 PhD students (nine in Italy, and one each from *Doctorat Astronomie et Astrophysique, Ecole Doctorale d'Astronomie et d'Astrophysique d'Ile-de-France, Observatoire de Paris, Open University, Danish Space Research Institute of Copenhagen, Manchester University*) and Supervisor of more than 50 Thesis of *Laurea Magistrale* (Master Degree) and several Thesis of *Laurea Triennale* at University of Milano. Over his career at Physics Department at Milano University, he has built a research group of about 12 people. The group is active in observational cosmology, radio and mm-wave astrophysics, microwave technology development. His group currently includes two Associate Professors (Davide Maino, Aniello Mennella), two Staff

Researchers (Maurizio Tomasi, Cristian Franceschet), four Research Associates, one Technician, three PhD Students. A number of former students of M.B.'s are continuing their career in high level astrophysics groups in Europe or USA.

Outreach & Inter-disciplinary activities

M.B. regularly gives public outreach conferences in Italy and abroad (on average 10-12 per year in the past 10 years) on astronomy, cosmology, science education, and exploring the connections between science and humanities. A few examples in past 10 years include: Bibliotheca Alexandrina (Egypt), 22 October 2018, *Under the same sky*; Università Piemonte Orientale, 10 Ottobre 2018, *L'universo nella scienza e nell'arte*; Barcelona, 4 October 2018, *El gran espectáculo del cel*; Politecnico di Milano, 6 June 2018, *Missione Planck, l'immagine dell'universo neonato*; Lyon, Université Jean Moulin, 25 May 2018, *Sulla geometria del cosmo dantesco*; Krakow, Copernicus Center, October 2017, *On the observability of the Early Universe*; Istituto Lombardo di Scienze e Lettere, 6 October 2016, *Dal cosmo dantesco all'universo di Planck*; Moscow, "Pokrovskie Vorota", 26 September 2015, *Se si accendono le stelle...*; Amsterdam, October 2013, World Science Festival, *Our Universe Exposed: Planck's Perfect Echo of the Past*; Bologna, 27 September 2013, *Origins*; Milano, 10 April 2013, *Missione Planck*, with Malcom Longair; Krakow, May 2014, *Exploring the limits of space-time*; DePaul University, Chicago, 7 March 2012, *At the Origin of the Universe*.

From 2007 to 2015 M.B. has promoted a series of yearly academic interdisciplinary symposia on frontier topics in science, held in the Summer at the University of San Marino (the "*San Marino Symposia*"), involving scientists and scholars. He has been also promoting large-scale science lectures at the Rimini Meeting, involving leading scientists, attended by several thousand people.

M.B. has published essays, books and book chapters on science and interdisciplinary topics, including *Solo lo stupore conosce*, Rizzoli 2003 (translated as *From Galileo to Gell-Mann*, Templeton Press, 2009); *Infinity and the Nostalgia of the Stars*, in «Infinity. New Research Frontiers», Cambridge University Press, 2011; *Light in the Beginning*, in «Light from light», Eerdmans, 2011; *Il grande spettacolo del cielo*, Sperling & Kupfer 2016. He wrote articles for some of the leading newspapers in Italy, participated in TV and radio interviews and press releases.

He co-authored about 20 scientific exhibitions, visited by tens of thousands of people in Italy, some of which were translated into English, Spanish, German, Arabic. M.B. is co-founder and Scientific Director of *Euresis* a free association for the promotion of science. Since 2016 he is in the Scientific Committee of the *Planetarium of Milano*. Since 2014 he has been part of the Editorial Board of the *Meeting for Friendship of Peoples*, and since 2020 of its Administration Council. Since 2012 he is President of *Sacro Cuore Foundation for the Education of the Young People*, managing a number of schools in Milano ranging from kindergarten to high school.