

# Shyam Balaji

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## Research Focus

Astroparticle physics and cosmology with particular interest in beyond the Standard Model phenomenology, dark matter, inflation, gravitational waves, cosmic rays, neutrinos and experimental anomalies.

## Research Positions

2023–current      Postdoctoral Fellow in Theoretical Particle Physics and Cosmology, King's College London, The Strand, London  
2021–2023      Postdoctoral Fellow in Theoretical Particle Physics, Laboratory for Theoretical and High Energy Physics (LPTHE), Jussieu, Paris

## Education

2017–2021      Ph.D., Physics, University of Sydney, Australia  
Thesis Title: Exploring Extended Scalar Sectors, Neutrinos and Flavour Anomalies  
Supervisor: Prof. Kevin Varvell and Prof. Céline Boehm  
2009–2014      B.Eng. (First Class Honours), Mechanical Engineering, University of Western Australia  
Thesis Title: Time-Domain Calculation of the Acoustical Wave Propagator for Discontinuous Media using a Mapped Pseudo-spectral Method in Multidimensional Space  
Supervisor: Prof. Jie Pan  
2009–2011      B.Sc., Physics and Applied Mathematics, University of Western Australia

## Visting Researcher

2024      University of Stockholm, Oskar Klein Centre, Stockholm, Sweden  
2023      University of Bologna, Bologna, Italy  
2023      University of Tokyo, Hongo, Bunkyo City, Tokyo  
2022      Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts  
2022      Harvard Smithsonian Center for Astrophysics, Cambridge, Massachusetts  
2022      Johns Hopkins University, Baltimore, Maryland  
2020      Imperial College London, London, United Kingdom  
2019      Institute for Particle Physics Phenomenology (IPPP), Durham, United Kingdom  
2019      Niels Bohr Institute, København, Denmark  
2019      European Organization for Nuclear Research (CERN), Meyrin, Switzerland  
2017      European Organization for Nuclear Research (CERN), Meyrin, Switzerland

## Professional Appointments

2018-current      Exotics Higgs Search Member, ATLAS experiment, European Organization for Nuclear Research (CERN), Meyrin, Switzerland  
2015-2016      Project Engineer, Technip Oceania, Perth, WA  
2012-2013      Undergraduate Pipelines Engineer, Intecsea, Perth, WA  
2011-2012      Undergraduate Mechanical Engineer, Proteus EPCM Engineers, Perth, WA

## Academic Service

- 2024-current Mentor, *academic mentor in the Success for Black Engineers and Scientists program in King's College London*
- 2024-current Organizer, *weekly seminar organiser for theoretical physics group in King's College London*
- 2023-current Member, *outreach and dissemination working group of COSMIC WISPerS in the Dark Universe*

## Selected Honours and Awards

- 2024 Short term scientific mission grant, *travel funding prize*
- 2022 Bragg medal nomination, *for best doctoral dissertation in physics from the University of Sydney*
- 2017-2021 Australia Postgraduate Award (APA), *doctoral scholarship for exceptional research potential*
- 2020 Paulette Isabel Jones Scholarship, *award acknowledging outstanding research*
- 2020 Postgraduate Research Support Scheme Scholarship, *meritocratic research scholarship*
- 2019 Royal Society of New South Wales Scholarship, *prize acknowledging outstanding achievement in scientific research*
- 2019 Physics Research Symposium Prize, *prize for winning talk*
- 2019 R. and M. Bentwich Scholarship, *travel scholarship for outstanding researcher*
- 2019 James Kentley Scholarship, *travel scholarship for outstanding researcher*
- 2019 Postgraduate Research Support Scheme Scholarship (PRSS), *meritocratic research scholarship*
- 2018 Postgraduate Research Support Scheme Scholarship, *meritocratic research scholarship*
- 2016 Spintronics and Magnetisation Dynamics, *summer research scholarship*
- 2016-2017 Jacques Franquelin Award Nomination (JFA), *award for excellence in innovation*
- 2014 Dean's List Award, *top of graduating class*
- 2008 99 Club, *top of graduating class*

## Research Supervision

- 2024-present Damon Cleaver, *project supervision, King's College London*
- 2023-2024 Jordan Koechler, *project supervision, LPTHE*
- 2022-2023 Wenzer Qin, *project supervision, Massachusetts Institute of Technology*

## Refereeing Experience

- 2023-current Physical Review D, *refereed 5 papers*
- 2024-current Journal of Cosmology and Astroparticle Physics, *refereed 1 paper*

## Teaching Experience (Courses)

- 2024-present Thermal Physics and Properties of Matter, King's College London
- 2024-present Mathematical Methods for Physics, King's College London
- 2018-2021 Astrophysics and Relativity (Advanced), University of Sydney
- 2017-2021 Physics 1 (Technological), University of Sydney
- 2018-2021 System Dynamics and Control, University of Sydney
- 2016-2016 Control Engineering, University of Western Australia
- 2012-2014 Control and Mechatronics, University of Western Australia
- 2013-2013 Fluid Mechanics, University of Western Australia
- 2013-2014 Applied Engineering Thermodynamics University of Western Australia
- 2012-2014 Motion, University of Western Australia
- 2010-2012 Engineering Dynamics, University of Western Australia
- 2010-2011 Engineering Mechanics, University of Western Australia

## Press and Media Engagement

- 2024-present Expert science consultant for Time magazine on the [Leonids meteor shower](#)
- 2024-present Expert science consultant for The Independent on the [Supermoon](#)

## Computational Experience

Languages	Python, C++, ROOT
Linux Computing	bash, git
Scientific Programming	Mathematica, Matlab, R
Cosmology	CLASS
Cosmic Rays	DRAGON
Machine Learning	Tensorflow, Keras, Scikit-learn, PyTorch
Collider Physics	MadGraph, Pythia, Rivet, FeynRules, CalcHEP, MadDM
Flavour Physics	flavio

## Invited Seminars, Conferences and Schools

- [1] 15th International Workshop on the Identification of Dark Matter 2024, May 2024, L'Aquila, Italy  
Talk: *New 511 keV line data provides strongest sub-GeV dark matter constraints*
- [2] UK Cosmology meeting, May 2024, London, UK
- [3] TeV Particle Astrophysics (TeVPA), Naples, Italy, September 2023
- [4] Talk: *Improved stellar limits on a light CP-even scalar*  
Bologna Physics and Astronomy seminar, Bologna, Italy, September 2023  
University of Tokyo Hongo High Energy Theory Group Seminar, April 2023  
IBS Daejeon Center for Theoretical Physics Seminar, June 2022
- [5] Cosmology 2023, Miramare, Trieste, Italy, August 2023
- [6] Majorana-Raychaudhuri seminar, May 2023  
Talk: *Observing nulling of primordial correlations via the 21 cm signal*
- [7] Particle Physicists Dining with Astrophysicists (SynCRETism), Chania, Greece, June 2022
- [8] The 24<sup>th</sup> International Conference From the Planck Scale to the Electroweak Scale. Paris, France, May 2022
- [9] Talk: *Asymmetry in flavour changing electromagnetic transitions of vector-like quarks.*  
IRN Terascale @ LPTC-Clermont, Clermont-Ferrand, France, October 2021  
University of Tokyo Hongo High Energy Theory Group Seminar, November 2021
- [10] Sydney Consortium for Particle Physics and Cosmology (SC-PPC), Camperdown, Australia, October 2020.  
Talk: *Probing CP-violation in the fermion transition dipole moment.*
- [11] School of Physics Symposium, Camperdown, Australia, October 2019.  
Talk: *Searches for Extended Higgs Sectors, Flavour Physics Anomalies and Dark Matter at the LHC.*
- [12] Talk: *More stringent constraints on the unitarised fermionic dark matter Higgs portal.*  
XXV International Symposium for Particle physics, String theory and Cosmology (PASCOS). Manchester, UK, July 2019  
The 22<sup>nd</sup> International Conference From the Planck Scale to the Electroweak Scale. Granada, Spain, June 2019
- [13] School of Physics Symposium, Camperdown, Australia, October 2018  
Poster: *Searching for extended Higgs sectors at the LHC*
- [14] Asia-Europe-Pacific School of High-Energy Physics (AEPSHEP). Quy Nhon, Vietnam, September 2018
- [15] ATLAS E/Gamma Workshop. Hamburg, Germany, November 2017  
Talk: *Photon reconstruction efficiency measurement from radiative Z-decays.*
- [16] CoEPP Annual Conference. Glenelg, Adelaide, February 2017

## Conferences Proceedings

[1] Multimessenger constraints for electrophilic feebly interacting particles from supernovae

P. De La Torre Luque, **S. Balaji** and P. Carenza

arxiv:2406.07316

Contribution to 58th Rencontres de Moriond on Very High Energy Phenomena in the Universe

## References

Prof. Joseph Silk

Johns Hopkins University and Oxford University

Prof. Céline Bøhm

University of Sydney

Prof. David Kaiser

Massachusetts Institute of Technology

Prof. Michael Spannowsky

Durham University

## Selected List of Publications

### Statistics

No. of Citations (total): 1534

h-index: 14

For more information please see [Inspire HEP profile](#)

Citations statistics for listed publications taken from the Inspire HEP database at [inspirehep.net](#) as of October 2024

### Main-authored in Theory and Phenomenology

- [1] 511 keV Galactic Photons from a Dark Matter Spike  
P. De La Torre Luque, **S. Balaji**, M. Fairbairn, F. Sala and J. Silk  
arxiv:2410.16379  
Undergoing review with the Journal of Cosmology and Astroparticle Physics
- [2] Anomalous ionization in the Central Molecular Zone by sub-GeV dark matter  
P. De La Torre Luque, **S. Balaji** and J. Silk  
arxiv:2409.07515  
Undergoing review with Physical Review Letters
- [3] Supermassive black holes from inflation constrained by dark matter substructure  
**S. Balaji**, S. Ando, M. Fairbairn, N. Hiroshima and K. Ishiwata  
arxiv:2408.11098  
Undergoing review with Physical Review D
- [4] Refining Galactic primordial black hole evaporation constraints  
P. De La Torre Luque, J. Koechler and **S. Balaji**  
arxiv:2406.11949  
Accepted for publication with Physical Review D
- [5]  $\gamma$ -rays from in-flight positron annihilation as a probe of new physics  
P. De La Torre Luque, **S. Balaji**, P. Carena and L. Mastrototaro  
arxiv:2405.08482  
Undergoing review with Physical Review Letters
- [6] Probing modified Hawking evaporation with gravitational waves from the primordial black hole dominated universe  
**S. Balaji**, G. Domènech, G. Franciolini, A. Ganz and J. Tånkle  
arxiv:2403.14309  
Accepted for publication with the Journal of Cosmology and Astroparticle Physics
- [7] Magnetogenesis with gravitational waves and primordial black hole dark matter  
**S. Balaji**, M. Fairbairn and M. O. O. Romacho  
arxiv:2402.05179 (2024)  
Phys. Rev. D **109** (2024) no.7, 075048
- [8] New 511 keV line data provides strongest sub-GeV dark matter constraints  
P. De La Torre Luque, **S. Balaji** and J. Silk  
arxiv:2312.04907 (2023)  
Astrophys. J. Lett. **973**, no.1, L6 (2024)
- [9] Importance of cosmic ray propagation on sub-GeV dark matter constraints  
P. De La Torre Luque, **S. Balaji** and J. Koechler

- arxiv:2311.04979 (2023)  
Astrophys. J. **968** (2024) no.1, 46
- [10] Robust constraints on feebly interacting particles using XMM-Newton  
P. De La Torre Luque, **S. Balaji** and P. Carenza  
arxiv:2307.13728 (2023)  
Phys. Rev. D **109** (2024) no.10, L101305
- [11] Multimessenger search for electrophilic feebly interacting particles from supernovae  
P. De La Torre Luque, **S. Balaji** and P. Carenza  
arxiv:2307.13731 (2023)  
Phys. Rev. D **109** (2024) no.10, 103028
- [12] Scalar-induced gravitational wave interpretation of PTA data: the role of scalar fluctuation propagation speed  
**S. Balaji**, G. Domenech and G. Franciolini  
arxiv:2307.08552 (2023)  
JCAP **10** (2023) 041
- [13] Dark Matter spikes around Sgr A\* in  $\gamma$ -rays  
**S. Balaji**, D. Sachdeva, F. Sala and J. Silk  
arxiv:2303.12107 (2023)  
JCAP **08** (2023) 063
- [14] Gravitational waves from multifield inflation with nonminimal couplings  
W. Qin, **S. Balaji**, S. Geller, E. McDonough, D. Kaiser  
arxiv:2303.02168 (2023)  
Phys.Rev.D **108** (2023) 4, 043508
- [15] Light scalar explanation for 18 TeV GRB 221009A  
**S. Balaji**, M. E. Ramirez-Quezada, J. Silk, Y. Zhang  
arXiv:2301.02258 (2022)  
Phys. Rev. D **107** (2023) no.8, 083038
- [16]  $\gamma$ -ray and ultra-high energy neutrino background suppression due to solar radiation  
**S. Balaji**  
arXiv:2211.03807 (2022)  
Phys.Lett.B **845** (2023) 138157
- [17] Observing nulling of primordial correlations via the 21 cm signal  
**S. Balaji**, H. V. Ragavendra, S. K. Sethi, J. Silk and L. Sriramkumar  
arXiv:2206.06386 (2022)  
Phys. Rev. Lett. **129** (2022) no.26, 261301
- [18] Improved stellar limits on a light CP-even scalar  
**S. Balaji**, P. S. B. Dev, J. Silk and Y. Zhang  
arXiv:2205.01669 (2022)  
JCAP **12** (2022), 024
- [19] Induced gravitational waves from slow-roll inflation after an enhancing phase  
**S. Balaji**, G. Domenech and J. Silk  
arXiv:2205.01696 (2022)  
JCAP **09** (2022), 016
- [20] Radio sky reveals primordial electron-proton interactions  
**S. Balaji**, M. E. Ramirez-Quezada and C. Bøehm,

arXiv:2204.13711 (2022)

- [21] Induced gravitational waves from the cosmic coincidence  
**S. Balaji**, J. Silk and Y. Wu  
arxiv:2202.00700 (2022)  
JCAP **06** (2022) no.06, 008
- [22] Asymmetry in flavour changing electromagnetic transitions of vector-like quarks  
**S. Balaji**  
arxiv:2110.05473 (2021)  
JHEP **05** (2022), 015
- [23] Cosmological bubble friction in local equilibrium  
**S. Balaji**, M. Spannowsky and C. Tamarit  
arXiv:2010.08013 (2020)  
JCAP **03** (2021), 051
- [24]  $CP$  asymmetries in the rare top decays  $t \rightarrow c\gamma$  and  $t \rightarrow cg$   
**S. Balaji**  
arXiv:2009.03315 (2020)  
Phys. Rev. D **102** (2020), 113010
- [25]  $CP$  violation in the neutrino dipole moment  
**S. Balaji**, M. Ramirez-Quezada and Y. L. Zhou  
arXiv:2008.12795 (2020)  
JHEP **12** (2020), 090
- [26] A unified  $SU(4)$  theory for the  $R_{D^{(*)}}$  and  $R_{K^{(*)}}$  anomalies  
**S. Balaji** and M. A. Schmidt  
arxiv:1911.08873 (2019)  
Phys. Rev. D **101** (2020) no.1, 015026
- [27]  $CP$ -violation and circular polarisation in radiative neutrino decays  
**S. Balaji**, M. E. Ramirez-Quezada and Y. Zhou  
arXiv:1910.08558 (2019)  
JHEP **04** (2020), 178
- [28] More stringent constraints on the unitarised fermionic dark matter Higgs portal  
**S. Balaji** and A. Kobakhidze  
arXiv:1812.10914 (2018)
- [29] Chiral  $SU(4)$  explanation of the  $b \rightarrow s$  anomalies  
**S. Balaji**, R. Foot and M. A. Schmidt  
arXiv:1809.07562 (2018)  
Phys. Rev. D **99**, no. 1, 015029 (2019)
- [30] A two dimensional analytical model for the study of ferromagnetic resonance responses of single and multilayer films  
**S. Balaji** and M. Kostylev  
Journal of Applied Physics **121**, no. 12, 123906 (2017)

#### Main-authored with ATLAS Collaboration

- [30] Search for a heavy CP-odd Higgs Boson decaying to a  $Z$  boson and a heavy CP-even Higgs boson  $H$  with  $A \rightarrow ZH \rightarrow \ell\ell b\bar{b}$  and  $\ell\ell WW$  produced in 13 TeV Collisions with the the ATLAS Detector

**S. Balaji** with ATLAS Collaboration (Morad Aaboud et al.)  
arXiv:2011.05639 (2020)  
Eur. Phys. J. C **81** (2021) no.5, 396

- [31] Electron and photon performance measurements with the ATLAS detector using the 2015–2017 LHC proton-proton collision data  
**S. Balaji** with ATLAS Collaboration (Morad Aaboud et al.)  
arXiv:1908.00005 (2019)  
DOI:10.1088/1748-0221/14/12/P12006  
JINST **14** (2019) no.12, P12006