

# 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	Organizer, <i>weekly seminar organiser for theoretical physics group in King's College London</i>
2023-current	Member, <i>outreach and dissemination working group of COSMIC WISPer in the Dark Universe</i>

## Selected Honours and Awards

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

## Research Supervision

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

## Refereeing Experience

2023-current	Physical Review D, <i>refereed 5 papers</i>
2024-current	Journal of Cosmology and Astroparticle Physics, <i>refereed 1 paper</i>

## Teaching Experience (Courses)

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

## Computational Experience

Languages	Python, C++, ROOT
Linux Computing	bash, git
Scientific Programming	Mathematica, Matlab, R
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 Boehm	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

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

### Main-authored in Theory and Phenomenology

- [1] Anomalous ionization in the Central Molecular Zone by sub-GeV dark matter  
P. De La Torre Luque, **S. Balaji** and Joseph Silk  
arxiv:2409.07515  
Undergoing review with Physical Review Letters
- [2] 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
- [3] Refining Galactic primordial black hole evaporation constraints  
P. De La Torre Luque, J. Koechler and **S. Balaji**  
arxiv:2406.11949  
Undergoing review with Physical Review D
- [4]  $\gamma$ -rays from in-flight positron annihilation as a probe of new physics  
P. De La Torre Luque, **S. Balaji**, P. Carenza and L. Mastrototaro  
arxiv:2405.08482  
Undergoing review with Physical Review Letters
- [5] 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  
Undergoing review with the Journal of Cosmology and Astroparticle Physics
- [6] 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
- [7] 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)

- [8] 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
- [9] 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
- [10] 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
- [11] 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
- [12] 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
- [13] 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
- [14] 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
- [15]  $\gamma$ -ray and ultra-high energy neutrino background suppression due to solar radiation  
**S. Balaji**  
arXiv:2211.03807 (2022)  
Phys.Lett.B **845** (2023) 138157
- [16] 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
- [17] 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
- [18] 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

- [19] Radio sky reveals primordial electron-proton interactions  
**S. Balaji**, M. E. Ramirez-Quezada and C. Bøhm,  
arXiv:2204.13711 (2022)
- [20] Induced gravitational waves from the cosmic coincidence  
**S. Balaji**, J. Silk and Y. Wu  
arxiv:2202.00700 (2022)  
JCAP **06** (2022) no.06, 008
- [21] Asymmetry in flavour changing electromagnetic transitions of vector-like quarks  
**S. Balaji**  
arxiv:2110.05473 (2021)  
JHEP **05** (2022), 015
- [22] Cosmological bubble friction in local equilibrium  
**S. Balaji**, M. Spannowsky and C. Tamarit  
arXiv:2010.08013 (2020)  
JCAP **03** (2021), 051
- [23]  $CP$  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
- [24]  $CP$  violation in the neutrino dipole moment  
**S. Balaji**, M. Ramirez-Quezada and Y. L. Zhou  
arXiv:2008.12795 (2020)  
JHEP **12** (2020), 090
- [25] 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
- [26]  $CP$ -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
- [27] More stringent constraints on the unitarised fermionic dark matter Higgs portal  
**S. Balaji** and A. Kobakhidze  
arXiv:1812.10914 (2018)
- [28] 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)
- [29] 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  $A \rightarrow ZH \rightarrow \ell\ell bb$  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