Sergio Sevillano Muñoz

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Research interests

My current research focuses on the effect of extra scalar degrees of freedom on our universe. On large scales, I have studied their impact on the Hubble tension and on the CMB visibility function through their collapse into compact objects. On short scales, I have explored fifth forces and screening mechanisms originating from non-minimal couplings to gravity, developing a code (`FeynMG`) that helps test them using collider data.

Current position

2023- **Post-doctoral position** at IPPP, **Durham University**, UK.
Collaborators: Dr. Djuna Croon and Dr. Francesca Chadha-Day.

Education

2020-2023 **PhD in Particle Cosmology** at **University of Nottingham**, UK.
Title: *FeynMG: Automating particle physics calculations in scalar-tensor theories.*
Supervisor: Prof. Edmund J. Copeland and Dr. Pete Millington

2019-2020 **Part III** in Applied Mathematics and Theoretical Physics at **Univeristy of Cambridge**, UK.
Essay: *Tunneling Transitions in Quantum Mechanics, Field Theory and Gravity.*
Supervisor: Prof. Fernando Quevedo.

2016-2019 **B.Sc** in Physics and Theoretical Physics at **University of Nottingham**, UK.
Third-year project: *Scalar Fields in Cosmology and the Swampland Conjecture.*
Supervisor: Prof. Edmund J. Copeland.

Selected talks

Title: **Addressing the Hubble tension with scalar fields**

- UNAM, Mexico (Apr 2024)
- University of Nottingham (Dec 2022)

Title: **How to study modified gravity as a particle theory and not collapse in the process**

- Perimeter Institute, Canada (Jul 2024)
- IPPP, Durham (Dec 2023)
- COSMOS'23, IFT, Madrid (Sep 2023)
- UKCosmo, Cambridge (May 2023)
- Cosmology from home (Jun 2024)
- Newcastle University (Dec 2023)
- PASCOS'23, California (Jul 2023)
- BritGrav'23, Southampton (Apr 2023)

Title: **CMB bounds on accreting Extended Dark Matter Objects**

- Cosmology from home (Jun 2024)
- Beyond WIMPS, Durham (Mar 2024)
- University of Nottingham (Jun 2024)

Computing skills

I have developed the following codes:

`MATHEMATICA:` **FeynMG**: A Feynrules subpackage for studying scalar-tensor theories within particle theory pipelines.

CMB accretion: A numerical code to predict and constrain the influence of Extended Dark Matter objects on the CMB visibility function.

`PYTHON:` **EDOBounds**: Repository for constraints on Extended Dark Matter Objects, allowing the plotting of various bounds combinations for any given shape or radius.

Publications

I was the main contributor to following papers:

[1] Sergio Sevillano Muñoz. "A particle's perspective on screening mechanisms". In: (July 2024). arXiv: 2407.08779 [hep-ph].

[2] Djuna Croon and Sergio Sevillano Muñoz. "Repository for extended dark matter object constraints". In: (July 2024). arXiv: 2407.02573 [astro-ph.CO].

[3] Djuna Croon and Sergio Sevillano Muñoz. "Cosmic microwave background constraints on extended dark matter objects". In: *JCAP* 2024.07 (July 2024), p. 060. DOI: 10.1088/1475-7516/2024/07/060.

[4] Sergio Sevillano Muñoz. "FeynMG: Automating particle physics calculations in scalar-tensor theories". PhD thesis. Nottingham U., Nottingham U., 2023.

[5] Edmund J. Copeland, Adam Moss, Sergio Sevillano Muñoz, and Jade M. M. White. "Scaling solutions as Early Dark Energy resolutions to the Hubble tension". In: *JCAP* 05 (2024), p. 078. DOI: 10.1088/1475-7516/2024/05/078. arXiv: 2309.15295 [astro-ph.CO].

[6] Sergio Sevillano Muñoz, Edmund J. Copeland, Peter Millington, and Michael Spannowsky. "FeynMG: A FeynRules extension for scalar-tensor theories of gravity". In: *Comput. Phys. Commun.* 296 (2024), p. 109035. DOI: 10.1016/j.cpc.2023.109035. arXiv: 2211.14300 [gr-qc].

[7] Edmund J. Copeland, Peter Millington, and Sergio Sevillano Muñoz. "Fifth forces and broken scale symmetries in the Jordan frame". In: *JCAP* 02.02 (2022), p. 016. DOI: 10.1088/1475-7516/2022/02/016. arXiv: 2111.06357 [hep-th].

Teaching experience

2023-2024 Tutor for first year physics course *'Foundations of physics'* at Durham University.

2020-2023 Workshop demonstrator for *'Quantitative physics'*, *'Quantum dynamics'*, *'Computing'*, *'Symmetries and action principles'*, *'Fourier analysis'* and *'Atoms, photons and fundamental particles'* at University of Nottingham.

2017-2022 Physics and Mathematics private tutor for A-level students.

Academic service

2024 - Interviewer for EuCAPT series of videos (starting in September 2024).

2023 - IPPP Postdoctoral Representative at RSCC Meetings in the Physics Department.

2022 - Referee for Physical Review Journal D and European Physical Journal C.

2022 - 2023 Web page editor for UK Cosmo.

2021 - 2023 Web page editor for the Particle Cosmology group at University of Nottingham, UK.

2021 - 2022 Coordinator of the '*Particle Cosmology Student Journal Clubs*', University of Nottingham, UK.

Outreach Activities

May 2024 20-min talk titled: "The expansion of the universe and the Hubble tension", Pint of Science, Durham

Mar 2024 40-min talk titled: "The expansion of the universe and the Hubble tension", Café Scientifiqué, Durham

Oct 2022 DigitalizArte: Undertook a +20 hours online course on using YouTube for communicating science.

2021- Multiple outreach talks on *"Quantum mechanics and philosophy of science"* at School CEU San Pablo, Spain.

2018- Uploaded multiple outreach videos to YouTube and Instagram about topics ranging from Classical dynamics to Early Universe topics.

Awards and Scholarships

Jun 2023 Paul Dirac prize at Erice International School of Subnuclear Physics for my contributions and special talent talk.

May 2023 Andrew Hendry Scholarship Endowed Award 2023 for my PhD trajectory.

Mar 2022 1st Prize in the 2022 Physics and Astronomy Poster competition at University of Nottingham, UK.

Sep 2020 STFC funding for 3.5 years to do a PhD at University of Nottingham, UK.

Jan 2017 Sir Peter Mansfield Award for excellent academic results at University of Nottingham, UK.

Official visits

Jun 2024 2-week visit to the Perimeter Institute, Waterloo, Canada.
Collaborator: Prof. Cliff Burgess.

Mar 2024 1-week visit to the Physics department of the University of Manchester, UK.
Collaborator: Dr. Peter Millington.

Jun 2022 1-week visit to the Physics department of the University of Glasgow, UK.
Collaborator: Prof. Christoph Englert.

Feb 2022 1-week visit to the Physics department of Durham University, UK.
Collaborator: Prof. Michael Spannowsky.

References

- **Prof. Edmund Copeland**
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- **Dr. Djuna Croon**
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- **Prof. Dr. Peter Millington**
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  University of Manchester
  Peter.millington@manchester.ac.uk