Premvijay **Velmani**

Senior Research Fellow · PhD

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Research

Cosmology and Large Scale Structure - Dark matter haloes, their evolution and distribution in the cosmic web - Galaxy formation, feedbacks and their impacts on host haloes - Cosmological (hydrodynamical) simulations, Analytical halo formation models and numerical experiments - Self-similar haloes and galaxies.

I primarily work on an interface between cosmology and astrophysics of galaxies, trying to understand and build a physical model of the impacts of galactic astrophysical processes on the dark matter haloes. This will not only make it easier to study cosmology and dark matter physics with haloes but also helps build a consistent picture of galaxy formation and evolution.

Experiences

PhD Research Fellow at IUCAA — *Pune, India*

PI: Prof. Aseem Paranjape — *2020-present*

- I have run N-body and hydrodynamics simulations of cosmological volumes using GADGET4 and SWIFT codes including some of the baryon astrophysics.
- Using structure finding codes such as ROCKSTAR and VELOCIraptor, I have made halo catolgues and merger trees.
- I have studied cosmological information such as matter power spectrum and various halo and galaxy properties in simulations.
- Besides my own simulations, I have also worked on simulations produced by large collaborations such as IllustrisTNG and EAGLE.
- I also worked on Self-similar models of halo formation and evolution along with galaxy formation.
- I also worked with semi-analytical models of dark matter haloes and galaxies and did numerical experiments with such models.
- In a mini project done with Prof. Hector marin, I have inferred cosmological parameters from eBOSS and mock DESI data.
- I am currently working in a data science collaboration focused on using machine learning techniques in cosmological data compression and inference.
- In another collobaration, I am working on the effect of supermassive black holes on the nature and the evolution of overall dark matter in the haloes.

Comprehensive training in modern Astrophysics research — *Pune, India*

1 year gradschool at IUCAA — *2019-2020*

- I was trained to write observation proposals and to collect and analyse data from several major missions.
- I was trained to perform and analyse simulations at different scales from ISM radiative transfer to haloes in the large scale structure.
- I was trained in several computational and statistical methods in Astrophysics.

MS Thesis at IISER Bhopal — *Bhopal, India*

PI: Prof. Sukanta Panda — *2018-2019*

- I worked on cosmological perturbations in an anisotropic Bianchi type-I background and its evolution in a Bouncing model.

Publications

The quasi-adiabatic relaxation of haloes in the IllustrisTNG and EAGLE cosmological simulations — *https://doi.org/10.1093/mnras/stad297*

Premvijay Velmani, Aseem Paranjape — *Published in MNRAS, 2023*

Properties beyond mass for unresolved haloes across redshift and cosmology using correlations with local halo environment — *https://doi.org/10.1093/mnras/stac2605*

Sujatha Ramakrishnan, Premvijay Velmani — *Published in MNRAS, 2023*

A self-similar model of galaxy formation and dark halo relaxation — *https://doi.org/10.1088/1475-7516/2024/05/080*

Premvijay Velmani, Aseem Paranjape — *Published in JCAP, 2024*

Dynamics of the response of dark matter halo to galaxy evolution in IllustrisTNG https://doi.org/10.1088/1475-7516/2025/02/006

Premvijay Velmani, Aseem Paranjape — *Published in JCAP, 2025*

The evolving role of astrophysical modelling in dark matter halo relaxation response https://doi.org//10.48550/arXiv.2408.04864

Premvijay Velmani, Aseem Paranjape — *Published in JCAP, 2025*

Conferences and Events

The Abdus Salam International Centre for Theoretical Physics — *Trieste, Italy*

Summer School on Cosmology 2022 — *July 2022*

- Presented a talk on "Impact Of Galaxy Formation On The Dark Matter Haloes In The Cosmic Web" at ICTP, an UNESCO organisation.

International Centre for Theoretical Sciences — *Bengaluru, India*

Largest Cosmological Surveys and Big Data Science 2023 — *April 2023*

- Worked on a mini project analysing redshift space distortion information from mock DESI data
- Presented a talk on "Impact Of Galaxy Formation On The Dark Matter Haloes In The Cosmic Web" at ICTP, an UNESCO organisation.

Inter-University Centre for Astronomy and Astrophysics — *Pune, India*

Pune-Mumbai Cosmology and Astro-Particle Meeting - 2 — *February 2024*

- Presented a talk on "Interplay of baryonic galaxies and their host dark haloes - Insights from self-similar analysis"

Tata Institute of Fundamental Research — *Mumbai, India*

Pune-Mumbai Cosmology and Astro-Particle Meeting - 3 — *September 2024*

- Discussion focussed meeting

Korea Institute for advanced Study(KIAS) — *Hilton Gyeongju, South Korea*

11th KIAS Workshop on Cosmology and Structure Formation — *October 2024*

- Presented a talk and a poster on "Interplay of galaxy formation and the evolution of dark matter haloes in the cosmic web - Dynamics of Relaxation".

Inter-University Centre for Astronomy and Astrophysics — *Pune, India*

Baryons Beyond Galactic Boundaries -2024 — *October 2024*

- Presented a poster and a talk on "Impacts of galactic astrophysics on their outskirts and dark haloes".

Other talks

Indian Institute of Science Education and Research, Pune — *Pune, India*

Last Friday Talk — *Jan 2024*

- Presented a talk on "A self-similar model of galaxy formation and dark halo relaxation".

Inter-University Centre for Astronomy and Astrophysics — *Pune, India*

Last Friday Talk — *November 2023*

- Presented a talk on "Impact Of Galaxy Formation On The Dark Matter Haloes In The Cosmic Web".

Inter-University Centre for Astronomy and Astrophysics — *Pune, India*

Last Friday Talk — *March 2024*

- Presented a talk on "A self-similar model of galaxy formation and dark halo relaxation".

Education

Inter University Centre for Astronomy and Astrophysics (IUCAA affiliated to JNU) — *Pune, Maharashtra*

Doctor of Philosophy (Gradschool) — *July 2019 - July 2024*

- One year of comprehensive grad school course work, focusing on practical things needed for research in different branches of Astronomy and Astrophysics.
- Thesis title: Interplay of galaxy formation and the evolution of dark matter haloes in the cosmic web
- Thesis advisor: Prof. Aseem Paranjape

Indian Institute of Science Education and Research (IISER) Bhopal *Bhopal, Madhya Pradesh*

Bachelor of Science and Master of Science (BS-MS) Dual Degree *August 2014 - May 2019*

- Obtained a CPI/CGPA of 9.4 with major in Physics and a minor in Mathematics.
- MS thesis: "Evolution of anisotropic perturbations in bouncing cosmology" under the guidance of Prof. Sukanta Panda.

Tamil Nadu Board of Secondary Education *Chennai, Tamil Nadu*

Class 12 - plus two *Graduated March 2014*

- **94.58** %, Obtained **96.25** % excluding language subjects.

Tamil Nadu Board of Secondary Education *Chennai, Tamil Nadu*

Class 10 - SSLC *Graduated April 2012*

- **93.6** %, Obtained **99.33** % excluding language subjects and 100 % in science.

Awards and fellowships

Aug.2021	**Senior Research Fellowship,** Inter-University Centre for Astronomy and Astrophysics	*Pune, India*
Aug.2019	**Junior Research Fellowship,** Inter-University Centre for Astronomy and Astrophysics	*Pune, India*
Jan.2019	**Junior Research Fellowship,** Council of Scientific & Industrial Research	*New Delhi, India*
Aug.2014	**INSPIRE Scholarship,** IISER, Department of Science & Technology	*Bhopal, India*
June.2014	**Cash Prize Award,** Second rank in 12th board exam	*Chennai, India*
April.2012	**SSLC cash prize award,** Centum in 10th board exam	*Chennai, India*

Professional Skills

Computer skills

Programming	Python, Bash, C, C++, IDL, Fortran, R, Wolfram, Matlab/Octave
Python libraries	Includes numpy, scipy, pandas, astropy, cobaya, camb, colossus, casa, h5py, sklearn, matplotlib, seaborn, getdist, pyqtgraph, vispy, vpython, pyopengl, pyopencl, pycuda, conda, mpi4py and PyQt5
Simulation tools	GADGET4, SWIFT, ROCKSTAR, VELOCIraptor, MUSIC2-monofonIC
Analytical tools	Mathematica (packages xTensor, xCoba, xPert, xPand), Maple, Python sympy
Operating system	Linux system administration, Bash, distros including Arch Linux, Ubuntu, Fedora, RHEL, SUSE, Centos; Windows administration, Visual Studio, Powershell, Windows Subsystem for Linux; Remote adinistration, SSH, HPC clusters with PBS jobs scheduler and NFS storage.
Markup Languages	LaTeX, HTML, CSS, Markdown, MS Office/ Libreoffice
Media creation	Adobe Creative Cloud apps, DaVinci Resolve, Blender, Poser, Audacity

Teaching skills

Physics Cosmology, Astrophysics, General relativity, Mathematical and Computational methods

Academic Achievements

May 2022	**Summer School on Cosmology 2022,** Invited with funds by ICTP, UNESCO	*Trieste, Italy*
Jun 2018	**CSIR UGC NET - Physics,** Qualified JRF with a score of 115 and all India rank of 116	*India*
Aril 2014	**JEE MAIN / AIEEE,** Qualified with a score 190	*India*
May 2014	**NEET UG / AIPMT,** Qualified with a score of 350.	*India*
June 2014	**JEE ADVANCED,** Qualified with a rank of **4056** within OBC category.	*India*
June 2016	**SOLOLEARN - Python,** Completed with certification	

Hobbies & Interests

I do a variety of things but usually they are connected to my strong curiousity, striving to understand each and every thing as I encounter in everyday life. This not only allows me to enjoy the beauty of nature from newer dimensions, I think this is necessary to develop myself and our civilisation as a whole. As a challenge seeking person I also enjoy this process of cracking the puzzles of nature.

Reading I use the world wide web to explore various topics in both natural science and others such as history, politics, technology and sustainable development, with a rational viewpoint.

Exploration I love to ocassionally go for trekking and also travel to experience various cultures and cuisines.

Sports I love to ocassionally take part in football, badminton, table tennis and swimming.

Other personality In my free time, I enjoy doing lots of home experiments driven by my own curiosity. And I can relate with prof. R Feynman that "Nearly everything is really interesting if you go into it deeply enough". I like challenges and I don't like doing simple things repetitively, so I keep exploring various new things. Trying to comprehend the logic behind complex things is my pleasure. I also love being more self-reliant not because I don't trusts others but simply I am eager to engage in every activity myself.

Extracurricular Activity

IUCAA open science day — *Pune, India*

Presented a poster on basics of cosmology — *Feb 2023*

IUCAA open science day — *Pune, India*

Created a video explaining probes of cosmology — *Feb 2021*

IUCAA open science day — *Pune, India*

Demonstrated creation of gravitational waves — *Feb 2019*

Singularity-15, IISER Bhopal — *Bhopal, India*

Bad Ad Hoc Hypothesis on gravity at the cosmic horizon — *April 2015*

Singularity-16, IISER Bhopal — *Bhopal, India*

Science Exhibition demonstration of a mega domino effect system — *September 2016*

IISER Science Council — *Bhopal, India*

Head of Artificial Intelligence and ML club; member of Physics, Mathematics and Astronomy Club — *Aug 2014 - May 2019*

Astronomy and Space Technology Awareness Camp — *Bhopal, India*

Workshop by spATs of IIT Kgp — *April 2015*

Mimamsa 2015 by IISER Pune — *Mumbai, India*

National Science Quiz — *January 2015*

Mimamsa 2016 by IISER Pune — *Bhopal, India*

National Science Quiz — *January 2016*

School level — *Chennai, India*

Competitions

- Winner in Science quiz intra school. Got selected in science talent exam conducted by The Hindu Educational Plus.
- Winner in debate about Education System.

References

Prof.Dr. Aseem Paranjape — *Pune, India*

Inter-University Centre for Astronomy and Astrophysics (IUCAA) — *aseem@iucaa.in*

Prof.Dr. Subhabrata Majumdar — *Mumbai, India*

Tata Institute of Fundamental Research (TIFR) — *subha@tifr.res.in*

Prof.Dr. Nishikanta Khandai — *Bhubaneswar, India*

National Institute of Science Education and Research (NISER) — *nkhandai@niser.ac.in*