Inter-University Centre for Astronomy and Astrophysics
Email: premv@iucaa.in; Mobile: +91-8056837468

November 29, 2024

Prof. Luisa Lucie-Smith
Universität Hamburg
Hamburg, Germany

Dear Prof. Lucie-Smith,

With extensive experience in analyzing cosmological simulations and designing controlled numerical experiments to model galaxy-halo connections, I am eager to apply for the postdoctoral position in your research group. Fascinated by your work using machine learning to study halo profiles and large-scale structure, I am excited about the opportunity to advance AI-driven approaches in cosmology with your group at Universität Hamburg.

Currently at IUCAA with Prof. Aseem Paranjape, I study the interplay between galaxies and their host dark matter haloes using hydrodynamical cosmological simulations such as IllustrisTNG, EAGLE, and CAMELS. My main focus is on understanding the impacts of galactic astrophysics on the dark matter halo and producing simple physical model that isolates these effects from other effects due to cosmology and dark matter physics on their spherically-averaged density profiles. I have also performed cosmological hydrodynamical simulation and explored halos, galaxies and the large-scale structure leveraging tools like GADGET, AREPO, MUSIC, ROCKSTAR, VELOCIraptor, etc.

Additionally, I have developed more tractable numerical experiments to study dynamical interactions between galaxies and their host dark matter haloes. While discussing one such experiment with self-similar techniques with Prof. Susmita Adhikari, I learned about some of the interesting insights about halo profiles from your work using machine learning approach.

While I got fascinated by the algorithmic approaches to learning nearly a decade ago, I have initially limited my use of techniques such as deep learning neural networks to non-scientific applications. I was reluctant that their black box nature might make it only more difficult in building a physical picture. However, later as I learned about interpretable techniques such as glass box models I got interested in their use in cosmology, especially fascinated by your works. As I recently started working in a collaboration focused on using ML techniques such data compression, etc, I realised the enormous potential of using the ML techniques as advanced computational statistics in understanding the Universe. Building on this foundation, I am eager to further develop my expertise in these ML techniques and combine with my strong expertise in performing and analysing simulations to understand more about galaxies and haloes in the cosmos.

In direct continuation of my current research, I have well-defined research plans, which aims to make significant contributions in understanding and modeling the astrophysical impacts on dark matter distribution within haloes and the large-scale structure. These long term research goals are closely aligned with the the primary work I expect to do with your group and hence ggreatly benefit from it in addition to the available computational resources.

The opportunity to join your group at Hamburg Observatory is especially appealing given its vibrant research environment and its emphasis on fostering interdisciplinary collaborations. I am

enthusiastic about engaging with colleagues in related fields, leveraging the observatory's ties to DESY and the Quantum Universe Cluster, and contributing to your group's exploration of novel machine learning methods in cosmology.

In addition to conducting original research, I am committed to advancing the principles of diversity and inclusion in academia. As an advocate for mentoring early-career researchers, I look forward to mentoring students and fostering a collaborative and inclusive research atmosphere. I also look forward to science popularisation activates of explaining elegant and intricate aspects of Universe through simpler analogies.

Thank you for considering my application. I look forward to discussing further about our research interests and plans.

Sincerely,
Premvijay Velmani,
Senior Research Scholar,
IUCAA Pune, India