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Asif Iqbal Ahangar

Curriculum Vitae

Education

2012 – 2017 **Doctor of Philosophy**, *Department of Physics, University of Kashmir, Hazratbal*, *Srinagar, J&K*, *190006*

Thesis Astrophysics and Cosmology with Sunyaev-Zel'dovich Effect in Galaxies, Groups and Cluster of Galaxies.

2010 – 2012 **Master of Philosophy**, *Department of Physics, University of Kashmir, Hazratbal*, *Srinagar, J&K*, *190006*

Dissertation Sunyaev-Zel'dovich Effect as a Probe of the Large Scale Structure of the Universe.

Professional Experience

2025 – present **Post-Doctoral Research Fellow**, *Unité de Recherche Pluridisciplinaire Sport, Santé, Société (URePSSS), Université de Lille*, *Loos, Lille, France*, *59000*
Bio-Mathematics, Modelling and Data science, applied to 'sport and diabetes' physiology.

2024 **Post-Doctoral Research Fellow**, *TIFR, Department of Theoretical Physics*, *Mumbai, Maharashtra, India*, *91191*
I. Developing deep learning models to study galaxy clusters.
II. Cosmology with galaxy clusters.

2019 – 2023 **Post-Doctoral Research Fellow**, *CEA Saclay, Dápartement d'Astrophysique, Ormes des Merisiers*, *Gif-sur-Yvette, Saclay, France*, *91191*
I. Part of X-ray working group in the CHEX-MATE collaboration and leading a project on developing a deep learning technique to study galaxy clusters.
II. Evaluating the quality of X-ray data in the CHEX-MATE sample.
III. Pipeline development to derive the science products from X-ray data and organizing the data/results in FITS format.
IV. Developed a numerical code for the cosmological parameter estimation with SZ power spectrum using Planck data.

2017 – 2019 **Post-Doctoral Research Fellow**, *Raman Research Institute, Raman Avenue, Sadashivanagar*, *Bengaluru, Karnataka*, *560080*
I. X-ray and radio data analysis and numerical modeling of sample of galaxy clusters.
II. X-ray, radio and lensing study of galaxy clusters.
III. X-ray and radio study of cosmological filaments.
IV. Study of cosmological models using CMB.

2013 – 2016 **Junior Research Fellow**, *Department of Physics, University of Kashmir, Hazratbal*, *Srinagar, J&K*, *190006*
I. Constraining the Cosmological Parameters and the underlying theoretical models with CMB anisotropy and polarization measurements.
II. Developed a numerical code to estimate the primordial power spectrum given any inflationary potential
III. Estimation of energy depositionz profiles in the galaxy clusters using the X-ray and SZ data.

2012 **Lecturer**, *Govt. Girls higher Sec. School, Soura*, Srinagar, J&K, *190020*
Teaching physics at higher secondary level.

Research Interests

Late Universe	X-ray and radio studies of galaxy clusters and galaxy groups, Sunyaev-Zel'dovich effect in galaxy clusters, Non-gravitational feedback in intra-cluster Medium (ICM), Dark matter profile, Gravitational lensing, Hot gas in galaxies.
Early Universe	Physics of early universe and inflation, Cosmological parameter estimation using Markov chain Monte Carlo (MCMC) algorithm and CMB data.
Bio-Mathematical Modeling	Developing and applying advanced machine techniques for analyzing physiological signals such as EEG and ECG, as well as studying the effects of physical activity on glucose levels in individuals with Type 1 Diabetes.
Data science	Big data, Deep learning, Data Visualization, Computing.

Skills

Operating Systems	Mac, Linux, Windows
Programming	**Languages**: C, C++, Fortran, Python, IDL, Scala, Matlab
	Core Concepts: Object-Oriented Programming, Data structures and Algorithms
	Machine learning: Supervised Learning, Unsupervised Learning Semi-supervised Learning
	Core Concepts: Linear Regression, Logistic Regression, Decision Trees, Random Forests, Support Vector Machines, k-means clustering and Hierarchical Clustering, Principal Component Analysis, Bayesian Analysis and various neural network architectures, etc
	MLOps: MLFlow, Scikit-learn, CI/CD, Azure, FastAPI, Gradio, SHAP, Docker, DVC, Flask
	Neural Networks: Pytorch, JAX, TensorFlow
	Core Concepts: FFN and CNN networks, Computer Vision, Natural Language Processing, Generative Modeling, etc
	Large Language Models: OpenAI API, Gemini API, Open-source LLMs, GPT, RAG, Vector Databases, LangChain Apps, Colab, Prompt Engineering, Bert
	Parallel Programming: OpenMP (C), multiprocessing (Python)
	Core Concepts: Concurrency vs. Parallelism, Parallel Programming Models, Synchronization, Load Balancing, etc.
	Cluster Computing: Slurm
	Core Concepts: Job Scheduling and Submission, Monitoring and Reporting, Resource Management, etc
	Scripting: Bash and Tcsh
	Core Concepts: Shell scripting, File handling, Functions, Error Handling and Debugging, etc
	Database: Spark, Hadoop, Elasticsearch, SQL (MySQL), Power BI, GitHub, Latex
	Core Concepts: Data Modeling, Queries, Repositorie, documentation, etc.
	Cloud Computing: AWS, Docker
	Core Concepts: Compute and storage services, Database Services, Monitoring and Management Tools, etc
Utility Softwares	**X-rays**: HEAsoft, Ciao (Chandra), SAS (XMM-Newton)—Imaging and spectral analysis
	CMB: CosmoMC, CAMB, MCMC — Inflation, CMB anomalies and cosmological parameter estimates
	Radio: CASA — Imaging (GMRT), APSYNSIM — Simulations
	Optical: Galaxy Photometry (IRAF, PHOTUTILS), Galaxy spectroscopy (IRAF, SPECUTILS) — Galaxy properties (SEXTRACTOR, GALFIT)
	Lensing: Grale, Lenstool — Mass distribution in galaxy clusters (modest experience)
Codes Developed	**Non-gravitational feedback in galaxy clusters** (C, C++): Numerical code to calculate non-gravitational feedback in intra-cluster medium.
	Deconvolution of temperature profiles in galaxy clusters (Python and idl): Developed parametric and non-parametric code for deconvolution of observed X-ray temperature profiles.

Primordial power spectrum (Fortran): Numerical code to calculate the primordial power spectrum using any inflationary potential (integrated with CosmoMC).

SZ power spectrum (C and Python): Numerical code for calculating SZ power spectrum for given cosmology and cluster physics (to be integrated with CosmoMC)

Fitting (C): Numerical code for Bayesian parameter estimation using MCMC and MC simulations

Time allocated for observing programs

- GMRT: obsid. $35-092$, observing Cycle 35 2018 (12hrs)
- GMRT: obsid. $39-085$, observing Cycle 39 2020 (PI, 12hrs)
- GMRT: obsid. $41-044$, observing Cycle 41 2021 (12hrs)
- GMRT: obsid. $43-023$, observing Cycle 43 2022 (108hrs)

Reviewer

2023-Present MNRAS.

Research Collaborations

2019-Present **CHEX-MATE collaboration:** Part of the X-ray working group to study galaxy clusters (website link).

2022-Present **The 300 simulations collaboration:** Part of the machine learning group to model galaxy clusters (website link).

Consortium Participation

2019-Present **Athena Europe:** Part of galaxy cluster group.

2018-Present **SKA India:** Part of radio continuum group of SKA, India.

Awards

2010 Awarded fellowship by University of Kashmir to pursue Master in Philosophy.

2012 Awarded fellowship by University of Kashmir to pursue Doctor in Philosophy.

2013 Awarded 3 year junior research fellow fellowship sponsored by Department of Science and Technology, Government of India.

2016 Awarded travel grant for summer school by ICTP.

2016 Awarded travel grant for summer school (ISYA) by IAU.

Miscellaneous Academic Activities

2012 – 2017 Regular visiting fellow at TIFR, IUCAA, RRI.

2013 – 2017 Assisted group of students every year for masters projects.

2015 Part of the local organizing Committee of 11th J&K Science Congress.

2016 Part of the local organizing Committee for XXXIV Meeting of Astronomical Society of India.

Key Research Accomplishments

- **CHEX-MATE collaboration** (working with core team): In 2019, I got a major opportunity to be part of the CHEX-MATE project (website link). I had the privilege of collaborating as a post-doctoral research fellow with the accomplished team at CEA, Saclay France. Their expertise in X-ray studies of galaxy clusters is widely recognized, and it was a valuable experience to be part of their core team. During this time, I gained proficiency in advanced X-ray data analysis techniques, became adept in managing data using fits files, and honed my skills in developing pipelines for extracting essential scientific insights from extensive datasets. I was involved in the quick-look X-ray data analysis of 118 CHEX-MATE clusters to quantify the quality of the X-ray data, the results of which were included in the first CHEX-MATE paper (**A&A, 650 (2021) A104**). I was also tasked to lead a project related to the implementation of the deep learning technique to the galaxy clusters using results from hydrodynamical simulations. We were able to developed, for the first time, a neural network model for the deconvolution and deprojection of thermal properties of the galaxy clusters. The technique learns lower-dimensional manifold of the date-sets to uncover the underlying physical model (**A&A 679 (2023) A51**). I was responsible for, in association with the Saclay team, (1) developing a deep learning model for galaxy clusters, (2) testing it on the high resolution hydrodynamical simulations and X-ray data and (3) developing a pipeline so that it can be applied on the full CHEX-MATE sample. We plan to further develop the model so as to use multi-wavelength data such as X-ray, SZ, optical and radio.
- **MNRAS, 518, 2023, 2735** (leading author): We studied two AGN heating models of ICM: the effervescent model and the acoustic model. With GMRT radio observations, we showed mechanical energy injected by the these two heating models correlates with cluster mass and that thermal conduction is important to transfer interjected energy from central to inner regions. I played a leading role in (1) developing the numerical code to implement feedback models, radiative cooling and conduction in galaxy clusters (2) simulating and debugging the code to study the cluster evolution. The clusters were allowed to evolve over their lifetime and (3) Comparing model profiles with X-ray, SZ and radio observations to constrain the feedback model parameters. I now plan to focus on improving the modeling that we recently developed to incorporate the cooling flows and convection which can significantly change the thermal structure of the clusters in the central regions.
- **MNRAS, 491 (2020) 2605** (contributing author and Co-PI of the GMRT proposal:) Using Chandra X-ray and GMRT radio data we should the interaction between hot gas in the filament connecting the two sub-clusters and the supermassive back hole. We were able to show the shock front at the site of collision where the jet is pushing the hot baryonic gas sideways. I played a role in (1) identifying the cluster, (2) formatting the GMRT proposal and (3) X-ray analysis. This work was highlighted on the NASA website (website link).
- **MNRAS Lett. 480 (2018) L68** (leading author): Using Chandra X-ray and VLA/GMRT radio data in the inner regions of 38 galaxy clusters, we found a significant correlation between the BCG radio-luminosity and cluster bulk properties indicating that bulk of the non-gravitational energy is sourced by the AGN. During this work, I got a opportunity to familiarize myself with radio data by collaborating with Ruta Kale (NCRA) who plays an important role in managing and upgrading the GMRT telescope. My work involved (1) sample selection (2) both the numerical modeling, data analysis and (3) model fitting to estimate the correlation between cluster properties. Since for many clusters we had only upper limits on the radio luminosity, robust fitting routine was used to take this into account.
- **JCAP, 06 (2015) 014** (leading author): We studied different inflationary driven primordial power spectra models to understand the nature of suppressed CMB power spectrum at large angular scales. We show that such scenarios, in general, lead to a better fit compared to the standard featureless power-law model. This project gave me an opportunity to add a new skills in developing (1) MCMC algorithms, (2) remote computing and (3) multiprocessing. I also learned to use the CMB data along with popular software packages like CosmoMC for the cosmological inferences which ultimately lead to the publication.

- **JCAP, 04 (2017) 013** (project leader, corresponding author): In this work, we showed that the punctuated inflation scenario wherein a break in the slow roll approximation could also result in power suppression at large angular scale and thus lead to moderate improvement in the CMB likelihood. This project gave me an opportunity to guide a junior P.hD student. I played a role in (1) fully developing a numerical code to estimate the primordial power spectrum given any inflationary potential, (2) integrating the code in CosmoMC, (3) assisting in parameter estimation and inference.
- **J. Astrophys. Astr. 36 (2017) 68** (leading author): We published a paper, as a part of the Indian SKA mission, about the impact that SKA can have in improving our understanding of AGN feedback in large-scale structures and its implications on the cosmology. I also got a wonderful chance to be part of SKA consortium and played an active role in deciding science goals for the SKA India in view of the DPR submission to the Department of Science and Technology, India (draft link).
- **MNRAS Lett. 465 (2017) L99** (leading author): We investigated the excess entropy and energy deposition profiles in galaxy clusters up to the virial radius in a sample of 17 galaxy clusters using joint data sets of Planck SZ pressure and ROSAT gas density measurements. The overall goal of this paper was to conclusively rule out the pre-heating of clusters. This effort was specifically important to understand the feedback in galaxy clusters. For this work, I collaborated with the primer institutes in India (TIRR and RRI). I also had the pleasure of work in international collaboration (Stefano Ettori, INAF, Italy and Dominique Eckert, University of Geneva, Switzerland). I played a main role in (1) checking the data for the scientific analysis and preparation of results (2) developing a numerical technique involving modeling of the galaxy clusters using observations as well as the simulations (3) MC sampling to estimate the feedback profiles.
- **MNRAS 472 (2017) 713** (leading author): We further examined the effects of gas clumping and non-thermal pressure on the estimated thermodynamic properties of the ICM and hence feedback profiles. This work suggests that both are vital to get the correct picture of feedback energetics in galaxy clusters. I played a leading role in (1) incorporating gas clumping and non-thermal pressure using hydrodynamical simulations (2) highlighting their importance (3) preparing the results.

Publications (in chronological order)

- *Joint Planck and WMAP Assessment of Low CMB Multipoles*
  Asif Iqbal, Jayanti Prasad, Tarun Souradeep, Manzoor A. Malik, JCAP, 06 (2015) 014
- *Little evidence for entropy and energy excess beyond r_{500}- An end to ICM preheating?*
  Asif Iqbal, Subhabrata Majumdar, Biman B. Nath, Stefano Ettori, Dominique Eckert, Manzoor A. Malik, MNRAS Lett. 465 (2017) L99
- *Low-ℓ power suppression in punctuated inflation*
  Mussadiq H. Qureshi, **Asif Iqbal**, Manzoor A. Malik, Tarun Souradeep, JCAP, 04 (2017) 013
- *Excess entropy and energy feedback from within cluster cores up to r_{200}*
  Asif Iqbal, Subhabrata Majumdar, Biman B. Nath, Stefano Ettori, Dominique Eckert, Manzoor A. Malik MNRAS 472 (2017) 713
- *AGN feedback with the Square Kilometer Array and implications for cluster physics and cosmology*
  Asif Iqbal, Ruta Kale, Subhabrata Majumdar, Biman B. Nath, Prateek Sharma, Mahadev Pandge, Somak Raychaudhury, Manzoor A. Malik, J. Astrophys. Astr. 36 (2017) 68
- *Correlations of the feedback energy and BCG radio luminosity in galaxy clusters*
  Asif Iqbal, Ruta Kale, Biman B. Nath, Subhabrata Majumdar MNRAS Lett. 480 (2018) L68
- *Confronting phantom inflation with Planck data*
  Asif Iqbal, Manzoor A. Malik, Mussadiq H. Qureshi, Astrophys. Space Sci. 363 (2018) 222
- *Complex Geometry of Space-time Motivated by Gravity's Rainbow*
  Faizan Bhat, Mussadiq H. Qureshi, Manzoor A. Malik, **Asif Iqbal**, CJP 97 (2019) 558
- *A rare case of FR I interaction with the hot X-ray bridge in A2384 galaxy cluster*
  V. Parekh, T. F. Laganá, K. Thorat, K. van der Heyden, **Asif Iqbal**, F. Durret MNRAS, 491 (2020) 2605

- *The Cluster HEritage project with XMM-Newton: Mass Assembly and Thermodynamics at the Endpoint of structure formation. I. Programme overview*
  The CHEX-MATE Collaboration, Arnaud, M. , Ettori, S, Pratt, G. W, ..., **A. Iqbal** et al., A&A, 650 (2021) A104
- *Heating of the intracluster medium by buoyant bubbles and sound waves*
  Asif Iqbal et al., MNRAS, 518 (2023) 2735
- *Exploring diffuse radio emission in galaxy clusters and groups with the uGMRT and the SKA*
  S. Paul, R. Kale, ..., **A. Iqbal** et al, 44, J. Astrophys. Astr,. (2023) 38
- *CHEX-MATE: constraining the origin of the scatter in galaxy cluster radial X-ray surface brightness profiles*
  I. Bartalucci, S. Molendi, ..., **A. Iqbal** et al., 674 A&A (2023) A179
- *CHEX-MATE: A non-parametric deep learning technique for the deconvolution of galaxy cluster X-ray temperature profiles*
  Asif Iqbal , G. W Pratt, J. Bobin, M. Arnaud, E. Rasia et al. 679 A&A (2023) A51
- *CHEX-MATE: A Multi-Probe Analysis of the 3-D Gas Shapes*
  J. Kim, J. Sayers, M. Sereno, ..., **A. Iqbal** et al., Accepted in A&A
- *The Evolution of X-ray galaxy Cluster Properties in a Representative Sample (EXCPRES) of luminosity-selected objects observed by XMM-Newton*
  C. Hubret M. Arnaud, E. Pointecouteau , G. W. Pratt, **A. Iqbal**, 688 A&A (2024) A219
- *CHEX-MATE: A LOFAR pilot X-ray – radio study on five radio halo clusters*
  M. Balboni, F. Gastaldello, A. Bonafede, ..., **A. Iqbal** et al., 686 A&A (2024) A5
- *CHEX-MATE: Robust reconstruction of temperature profiles in galaxy clusters with XMM-Newton*
  M. Rossetti, D. Eckert, F. Gastaldello, E. Rasia, G.W. Pratt, ..., **A. Iqbal** et al., 686 A&A (2024) A68

Work in progress

- *A deep learning technique to probe the ICM-dark matter connection in galaxy clusters using X-ray data*
  A. Iqbal et al.
  Developing a neural network code to map the thermal properties of the ICM with cluster mass profile.
- *Weighing Galaxy clusters with Deep learning technique*
  A. Iqbal et al.
  Developing a neural network code to map the thermal properties of the ICM with cluster total mass.

Workshops/Conferences/Talks/Posters

- Advanced statistical techniques in astronomy, 2010, IUCAA
- Winter school on astronomical and cosmological surveys, 2012, TIFR, India
- One week short term course on research methodology in science (using statistical softwares), 2012, University of Kashmir, India
- 2nd IUCAA X-ray astronomy School, 2013, IUCAA, India, **contributed talk**
- Present observational constraints on the cosmological parameters, 2013, Delhi University, India
- Frontiers in accelerator based physics, 2014, University of Kashmir, India
- Joint IUCAA-ISI workshop on data analysis on statistical applications to cosmology and astrophysics, 2015, ISI, India
- 11th J&K science congress, 2015, University of Kashmir, India, **contributed talk**
- 34th meeting of astronomical society of India, 2016, Kashmir University, Kashmir, Hazratbal, India, **contributed talk**
- Summer school on cosmology, 2016, ICTP, Italy, **poster presentation**
- The international school for young astronomers (ISYA-IAU), IPM, Iran 2016, **contributed talk**

- Entropy excess and energy deposition profile in galaxy clusters, University of Kashmir, India 2016, **seminar**
- Joint WMAP and Planck assessment of low CMB multipoles, University of Kashmir, India 2016, **seminar**
- Little evidence for entropy and energy excess beyond r_{200}, NCRA, India 2016, **seminar**
- Workshop on data analysis and LAXPC science, 2017, TIFR, India,
- Data intensive science workshop, 2017, IUCAA, India
- Chandra/CIAO workshop, 2017, NCRA, India
- An end to ICM pre-heating?, RRI, India 2017, **seminar**
- Neighborhood Astronomy meeting, IIA, India 2018, **contributed talk**
- Cosmology - The Next Decade, ICTS, India 2019, **contributed talk**
- Chandra Data Science: Novel Methods in Computing and Statistics for X-ray Astronomy, USA 2021, **contributed talk**
- Athena School, France, 2022
- Weighing galaxy clusters with deep learning technique, 300 simulations workshop, Spain, 2024, **contributed talk**
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Languages

English	Fluent (speaking, reading, writing)
Urdu	Fluent (speaking, reading, writing)
Hindi	Fluent (speaking)
French	Basic (speaking, reading, writhing)
Kashmire	Native language