Irshad Mohammed

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Date of Birth: 27 Dec 1986
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Education

University of Zürich, Zürich, Switzerland
Doctor of Philosophy - Physics, September 2015
Dissertation: Distribution of Matter in the Universe: from Lensing Clusters to Large Scale Structure

University of Bonn, Bonn, Germany
Masters of Science - Astrophysics, September 2012
Dissertation: Forecasts on Cosmology and Cluster Physics for the eROSITA X-ray Telescope

University of Delhi, Delhi, India
Bachelors of Science - Physics, July 2007

Research Interests

Computational cosmology, dark-matter and dark-energy, statistical inference, data mining, machine learning, high performance scientific computing.

Research Experience

Nov, 2015 - Now — **Fermi National Accelerator Laboratory.** — *Research Associate Post-Doctoral Fellow* — Batavia, Illinois, USA

Pursuing research in extra-galactic astrophysics and theoretical cosmology. I mainly focus on the computational and statistical aspects. In particular my interests lie in dark-matter clustering, statistical description of the energy content of the Universe, dark-energy, gravitational lensing etc. Current focus is on alternate statergies like predictive modeling using machine learning, and genetic algorithms. Part of my efforts are directed at the implementation of semi-analytical models in python and C++.

Oct, 2012 - Sep, 2015 — **Physics Institute and Institute for Computational Sciences, University of Zürich** — *Graduate Researcher, PhD* — Zürich, Switzerland

Developed analytic models for the statistical properties of the dark-matter clustering and its evolution. I employed analytic techniques, large box simulations, non-linear curve fitting tools etc. The implementations were written in Python (numpy, scipy). Further explored the possible systematic errors in the future generation surveys, like Euclid and LSST, and performed the statistical estimation and inference of the cosmological parameters and possible biases due to the systematics. Extended a gravitational lensing tool, called GRALE, using genetic algorithm (in C++) to incorporate additional signals in the similar data.

Mar, 2015 - April, 2015 — **Lawrence Berkeley National Laboratory** — *Visiting Researcher* — Berkeley, California, USA

Developed an analytic model for the covariance matrix of the matter power spectrum which quantifies the statistical properties of the dark-matter in the Universe.

Jan, 2014 - June, 2014 — **Lawrence Berkeley National Laboratory** — *Visiting Researcher* — Berkeley, California, USA

Developed an analytic model for the clustering of matter in the Universe. This model predicts

observations and simulations with 1-2 % accuracy which is 5 times better than previous studies. Also wrote Fortran90 and Python implementation of the model.

Oct, 2011 - Sep, 2012 **Argelander Institute for Astronomy, University of Bonn.** *Graduate Researcher* Bonn, Germany

Built models to forecast the cosmological results of the X-ray satellite telescope eRosita (German and Russian mission) using Fisher matrix analysis and Markov-Chain Monte-Carlo (MCMC).

Skills

Programming Languages

Python (numpy, scipy, sklearn), C++, Fortran90, Bash, SQL

Parallel Computing

OpenMP, MPI using Fortran90 and Python

Statistical Skills

Bayesian Statistics, Maximum Likelihood Analysis, Markov-chain Monte-Carlo (MCMC), Fisher Matrix Analysis, Machine learning, Genetic Algorithm and other standard optimizaion techniques

Awards and Fellowships

- Post-Doctoral Research Fellowship, *Fermi National Accelerator Laboratory, Batavia, Illinois, USA* (2015 - 2018)
- Graduate Research Fellowship *Physics Institute, University of Zurich, Switzerland* (2012 - 2015)
- Scholarship Plus, *University of Bonn, Germany* (2010 - 2012)
- Best Student of Physics and Electronics Department, *ARSD College, University of Delhi, India* (2007)
- Dr. Inder Raj Dhawan Scholarship, *ARSD College, University of Delhi, India* (2007)
- President of Physics Society *ARSD College, University of Delhi, India* (2006 - 2007)

Teaching

University of Zurich, Switzerland (3 years)

- **Methematical Methods in Physics**, Spring 2013
- **Programming in Biology**, Fall 2013
- **Physics Laboratory**, Fall 2014
- **Introduction to Astrophysics**, Spring 2015

University of Bonn, Germany (1 year)

- **Cosmology**, Fall 2011
- **Observational Cosmology**, Spring 2012

Publications

- **I. Mohammed**, J. Verma. *A supervised machine learning estimator for the non-linear matter power spectrum: SEMPS*. Submitted to MNRAS, July 2015.
  http://arxiv.org/pdf/1507.04622.pdf
- Kevin Sebasta, L. L. R. Williams, **I. Mohammed**, P. Saha, J. Liesenborgs. *Testing light-traces-mass in Hubble Frontier Fields Cluster MACS-J0416.1-2403*. Submitted to MNRAS, July 2015.
  http://arxiv.org/pdf/1507.08960.pdf
- **I. Mohammed**, P. Saha, L. L. R. Williams, J. Liesenborgs, Kevin Sebasta. *Quantifying substructures in Hubble Frontier Field clusters: comparison with ΛCDM simulations*. Submitted to MNRAS, July 2015.
  http://arxiv.org/pdf/1507.01532.pdf
- R. Massey, L. L. R. Williams, R. Smit, M. Swinbank, T. Kitching, D. Harvey, H. Israel, M. Jauzac, D. Clowe, A. Edge, M. Hilton, E. Jullo, A. Leonard, J. Liesenborgs, J. Merten, **I. Mohammed**, D. Nagai, J. Richard, A. Robertson, P. Saha, R. Santana, J. Stott, E. Tittley. *The behaviour of*

dark matter associated with 4 bright cluster galaxies in the 10kpc core of Abell 3827. Accepted for publication in MNRAS, April 2015.
http://arxiv.org/pdf/1504.03388v1.pdf

- **I. Mohammed**, P. Saha, J. Liesenborgs. *Lensing time delays as a substructure constraint: a case study with the cluster SDSS J1004+4112.* PASJ 10.1093/pasj/psu155, April 2015.
http://arxiv.org/pdf/1412.3464v1.pdf
- **I. Mohammed**, D. Martizzi, R. Teyssier, A. Amara. *Baryonic effects on weak-lensing two-point statistics and its cosmological implications*. Submitted to MNRAS, October 2014.
http://arxiv.org/pdf/1410.6826.pdf
- **I. Mohammed**, U. Seljak. *Analytic model for the matter power spectrum, its covariance matrix and baryonic effects*. MNRAS 10.1093/mnras/stu1972, September 2014.
http://arxiv.org/pdf/1407.0060.pdf
- K. Borm, T. H. Reiprich, **I. Mohammed**, L. Lovisari. *Constraining galaxy cluster temperatures and redshifts with eROSITA survey data*. A&A 10.1051/0004-6361/201322643, July 2014.
http://arxiv.org/pdf/1404.5312.pdf
- **I. Mohammed**, J. Liesenborgs, P. Saha, L. L. R. Williams. *Mass-galaxy offsets in Abell 3827, 2218 and 1689: intrinsic properties or line-of-sight substructure?*. MNRAS 10.1093/mnras/stu124, April 2014.
http://arxiv.org/pdf/1402.4217.pdf
- D. Martizzi, **I. Mohammed**, R. Teyssier, B. Moore. *The biasing of baryons of on the cluster mass function and cosmological parameter estimation*. MNRAS 10.1093/mnras/stu440, May 2014.
http://arxiv.org/pdf/1307.6002v1.pdf

Talks and Presentations

- *Towards Precision Cosmology: The Halo Model and Necessary Modifications* — *Conference*
International Center for Theoretical Physics (ICTP), Trieste, Italy (May 14, 2015)
- *Towards precision cosmology: the halo model and necessary modifications* — *Seminar*
Lawrence Berkeley National Laboratory (LBNL), Berkeley, California, USA (March 27, 2015)
- *Analytic model for the matter power spectrum: its covariance matrix and baryonic effects* — *Conference*
Swiss Cosmology Days 2015, Geneva, Switzerland (February 6, 2015)
- *Towards precision cosmology: the halo model and necessary modifications* — *Seminar*
Fermi National Accelerator Laboratory (Fermilab), Chicago area, Illinois, USA (January 20, 2015)
- *Towards precision cosmology: the halo model and necessary modifications* — *Seminar*
Department of Physics and Astrophysics, University of Delhi, New Delhi, India (January 14, 2015)
- *Towards precision cosmology: the halo model and necessary modifications* — *Workshop*
Centre for Theoretical Physics (CTP), Jamia University, New Delhi, India (January 6, 2015)
- *Towards precision cosmology: the halo model and necessary modifications* — *Seminar*
Department of Physics, University of Geneva, Switzerland (December 19, 2014)
- *Towards precision cosmology: dark matter clustering, covariance matrix and baryonic effects* — *Seminar*
Paris Observatory, Paris, France (November 20,, 2014)
- *Towards precision cosmology: the halo model and necessary modifications* — *Seminar*
Institute for Computational Science, University of Zurich, Zurich, Switzerland (December 12, 2014)
- *Analytic model for matter power spectrum and baryonic effects* — *School*
International Center for Theoretical Physics (ICTP), Trieste, Italy (August 11, 2014)
- *Baryonic effects in lensing statistics* — *School*
Essential Cosmology for the Next Generation, Mexico (January 13, 2014)

Conferences

- *Advanced Workshop on Cosmological Structures from Reionization to Galaxies* — *Presented a talk*
International Centre for Theoretical Physics (ICTP), Trieste, Italy (May 2015)

- *Workshop on Cosmology with Large Scale Structures* *Presented a talk*
  Centre for Theoretical Physics (CTP), Jamia University, New Delhi, India (January 2015)
- *Summer school on cosmology* *Presented a talk*
  International Centre for Theoretical Physics (ICTP), Trieste, Italy (August 2014)
- *Good Sense and Dominant Ideology in Galaxy and Planet Formation and Evolution*
  Ascona, Switzerland (July 2014)
- *School on essential cosmology for next generation* *Presented a talk*
  Los Cabos, Mexico (January 2014)
- *Mind the Gap, from microphysics to large-scale-structures of the Universe* *Presented a poster*
  University of Cambridge, UK (July 2013)
- *LSS13 conference*
  Ascona, Switzerland (July 2013)
- *1st eROSITA conference* *Presented a poster*
  Garmisch, Germany (October 2011)
- *Chandrayaan-I conference*
  Physical Reserach Laboratory, Ahmedabad, India (March 2009)
- *9th PLANEX workshop on Remote-sensing of inner-solar system objects* *Presented a talk*
  Rajasthan University, India (January 2009)
- *4th Amal Kumar Raychaudhary special school on general relativity and cosmology*
  Saha Institute of Nuclear Physics, Kolkata, India (October 2008)