Mohammadreza Ayromlou

Postdoctoral Researcher at Heidelberg University
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Education and Employment

- **Postdoctoral Researcher** — Dec 2021 - Present
  Center for Astronomy (ZAH), Heidelberg University — *Heidelberg, Germany*
  - Research focused on the interplay between galaxy evolution processes and large-scale structure
- **Postdoctoral Researcher** — Apr 2021 - Nov 2021
  Max Planck Institute for Astrophysics (MPA) — *Garching, Germany*
  - Short bridging postdoc following my Ph.D.
  - Research focused on the interplay between galaxy evolution processes and large-scale structure
- **Ph.D., Physics (Astrophysics and Cosmology Concentration)** — Jul 2017 - Mar 2021
  Ludwig-Maximilians-Universität München and MPI for Astrophysics (MPA) — *Munich, Germany*
  - Thesis: Physical processes that determine the clustering of different types of galaxies on large scales, under the supervision of Prof. Guinevere Kauffmann and Prof. Simon D. M. White
- **M.Sc., Physics (Astrophysics and Cosmology Concentration)** — Sep 2014 - Aug 2016
  Sharif University of Technology — *Tehran, Iran*
  - Thesis Title: The study of cosmological structure formation by physics of stochastic processes
  - Thesis Score: 20/20, Total GPA: 18.15/20
- **B.Sc., Physics** — Sep 2009 - Aug 2014
  University of Tehran — *Tehran, Iran*

Research Interests and Methods

- **Research: Interplay between Galaxy Evolution, Gas, and Large-Scale Structure**
  - Galaxy formation and evolution within haloes, in halo outskirts, and beyond
  - Black hole (AGN) feedback
  - The environmental dependence of galaxy evolution
  - Gas distribution and kinematics in the Circumgalactic Medium and out to several Megaparsecs scales in the Intergalactic Medium (IGM)
  - Correlations between galaxy properties from small to large scales (Galactic Conformity)
- **Method: Theoretical Modeling and Numerical Simulations**
  - Developing, performing and analyzing cosmological hydrodynamical simulations and semi-analytical models. Recent projects in which I have led or been highly involved include:
    - The Munich semi-analytical model, L-Galaxies (Ayromlou+ 2021b version)
    - TNG-Cluster magnetohydrodynamical (MHD) simulation: A set of zoom simulations of 352 galaxy clusters
    - **PI of the project "Beyond"** (ongoing): A series of cosmological and zoom hydrodynamical simulations, devising a new set of sophisticated AGN feedback models.
  - Analyzing observational data, and Statistical Methods in Cosmology and Astrophysics

Publications (Reverse Chronological Order)

First author papers

1. An Atlas of the Gas Motions in the TNG-Cluster Simulation: from Cluster Cores to the Outskirts (Submitted to A&A) - Paper on ADS
   - **M. Ayromlou**, D. Nelson, A. Pillepich, E. Rohr, N. Truong, Y. Li, A.Simionescu, K.Lehle, W.Lee

2. Feedback reshapes the baryon distribution within haloes, in halo outskirts, and beyond: the closure radius from dwarfs to massive clusters (Published in MNRAS, 2023) - Paper on ADS
   - **M. Ayromlou**, D. Nelson, A. Pillepich

3. The Physical Origin of Galactic Conformity: From Theory to Observation (Published in MNRAS, 2023) - Paper on ADS, Data
   - **M. Ayromlou**, G. Kauffmann, A. Anand, S. D. M. White

4. Galaxy formation with L-GALAXIES: Modelling the environmental dependency of galaxy evolution and comparing with observations (Published in MNRAS, 2021) - Paper on ADS, Data
   - **M. Ayromlou**, G. Kauffmann, R. M. Yates, D. Nelson, S. D. M. White

5. Comparing galaxy formation in the L-GALAXIES semi-analytical model and the IllustrisTNG simulations (Published in MNRAS, 2021) - Paper on ADS, Data
   - **M. Ayromlou**, D. Nelson, R. M. Yates, G. Kauffmann, M. Renneby, S. D. M. White

6. A New Method to Quantify Environment and Model Ram-Pressure Stripping in N-Body Simulations (Published in MNRAS, 2019) - Paper on ADS, Data
   - **M. Ayromlou**, D. Nelson, R. M. Yates, G. Kauffmann, S. D. M. White

Second/Third author papers

7. Unveiling the (in)consistencies among the galaxy stellar mass function, star formation histories, satellite abundances and intracluster light from a semi-empirical perspective (Submitted to MNRAS, 2024) - Paper on ADS
   - H. Fu, F. Shankar, M. Ayromlou et al.

8. Introducing the TNG-Cluster Simulation: overview and physical properties of the gaseous intracluster medium (Submitted to A&A, 2023) - Paper on ADS
   - D. Nelson, A. Pillepich, M. Ayromlou, W. Lee, K. Lehle, E. Rohr, N. Truong

9. Testing the key role of the stellar mass-halo mass relation in galaxy merger rates and morphologies via DECODE, a novel Discrete statistical sEmi-empiriCal mODEl (Published in MNRAS, 2022) - Paper on ADS
   - H. Fu, F. Shankar, M. Ayromlou et al.

10. The Excursion set approach: Stratonovich approximation and Cholesky decomposition (Published in MNRAS, 2018) - Paper on ADS
    - F. Nikakhtar, M. Ayromlou, S. Baghram, S. Rahvar, M. R. R. Tabar, R. K. Sheth

Co-Author Papers

11. The hot circumgalactic media of thousands of massive cluster satellites with the TNG-Cluster simulation, and how to detect them (Submitted to A&A) - Paper on ADS
    - E. Rohr, A. Pillepich, D. Nelson, M. Ayromlou, E. Zinger

12. X-ray inferred kinematics of the core ICM in Perseus-like clusters: insights from the TNG-Cluster simulation (Submitted to A&A) - Paper on ADS
    - N. Truong et al. (incl. M. Ayromlou)

13. MUSE-ALMA Haloes IX: Morphologies and Stellar Properties of Gas-rich Galaxies (Published in MNRAS, 2023) - Paper on ADS
    - A. Karki et al. (incl. M. Ayromlou)

14. A Virgo Environmental Survey Tracing Ionised Gas Emission (VESTIGE) XV. The Halpha luminosity function of the Virgo cluster (Published in A&A, 2023) - Paper on ADS
    - A. Boselli et al. (incl. M. Ayromlou)

15. Jellyfish galaxies with the IllustrisTNG simulations – When, where, and for how long does ram pressure stripping of cold gas occur? (Published in MNRAS, 2023) - Paper on ADS
    - E. Rohr, A. Pillepich, D. Nelson, E. Zinger, G. Joshi, M. Ayromlou

White papers

16. Exploring chemical enrichment of the intracluster medium with the Line Emission Mapper (LEM IGM White Paper, 2023)
    - F. Mernier et al. (incl. M. Ayromlou)

17. Line Emission Mapper (LEM): Probing the physics of cosmic ecosystems (LEM White Paper, 2022)
    - R. Kraft et al. (incl. M. Ayromlou)

Presentations and (Invited) Talks

- **Invited Prize Talk**: The Closure Radius, a theoretically reliable, empirically testable solution to the missing baryon problem: Patzer Prize talk (Nov 2023)
- **Invited Talk**: AGN feedback redistributes gas from small to large scales: Instituto de Astrofísica de Canarias (Oct 2023)
- TNG-Cluster simulation: The velocity structure of galaxy clusters from the cores to outskirts: MPE Garching (Sep 2023)
- Feedback, baryon redistribution, and the Closure Radius: EAS meeting, Krakow (Jul 2023)
- The interplay between galaxy evolution, gas, and large-scale structure: Multiphase gas conference, Kochel am See (Jun 2023)
- The Closure Radius: What physical processes impact the large-scale redistribution of baryons across different halo mass ranges: MPIA, Heidelberg (May 2023)
- The large-scale distribution of baryonic matter: MPA Garching (Mar 2023)
- Baryon redistribution due to Feedback and applications for future X-ray surveys: LEM Meeting CfA, Massachusetts (remote, Mar 2023)
- Feedback reshapes baryon distribution within haloes, in halo outskirts, and beyond: the closure radius from dwarfs to massive clusters: HERA Meeting, ORIGINS, Garching (Feb-Mar 2023)
- The Closure Radius: MMC conference, ESO Garching (Dec 2022)
- Galaxy evolution meets large scale structure, from dwarfs to clusters: UCL, London (Nov 2022)
- **Invited Talk**: Galactic Conformity, environmental effects and the future of L-Galaxies, the Munich semi-analytical model of galaxy formation: L-Galaxies workshop, Hertfordshire-London (Nov 2022)
- The interplay between galaxy evolution, gas, and large-scale structure of the universe: ISSI meeting, Bern (Oct 2022)

- **Invited Talk**: The recent developments of the Munich semi-analytical model: L-Galaxies day, MPA (July 2022)
- Galaxy evolution meets large scale structure; Galactic Conformity: MPA, Munich (July 2022)
- The distribution and kinematics of baryonic and dark matter out to large scales: Virgo Meeting (July 2022)
- **Invited Tutorial**: IllustrisTNG simulations: DAWN Winter School (Feb 2022)
- Galaxy Formation in the L-Galaxies and IllustrisTNG models: INO conference (Feb 2022)
- **Invited Talk**: Galaxy formation meets large scale structure: IPM (Jan 2022)
- Galaxy formation with L-Galaxies: KooGiG Conference, Peking (Nov 2021)
- The Physical Origin of Galactic Conformity: From Theory to Observation: Ringberg Meeting, Tegernsee (July/Aug 2021)
- **Invited Talk**: L-Galaxies: Modelling hundreds of millions of galaxies, public data release: INAF - Osservatorio Astrofisico di Arcetri (July 2021)
- L-Galaxies: Modelling the environmental dependency of galaxy evolution: Sharif University of Technology (July 2021)
- **Invited Talk**: L-Galaxies: Physics and Public data release: UMass Lowell (Apr 2021)
- **Invited Talk**: The formation and evolution of the Universe: Public talk at AstroZoom (Apr 2021)
- How galaxies are influenced by their environment up to large-scales: Virgo meeting (Jan 2021)
- The role of environment in galaxy evolution: Durham University (Dec 2020)
- Modeling the properties of galaxies in different environments: LMU Munich (Dec 2020)
- The environmental dependency of galaxy evolution from theory to observations: ESO (Dec 2020)
- Galaxy formation with L-Galaxies: Modelling the environmental dependency of galaxy evolution and comparing with observations: Leiden Observatory (Nov 2020)
- A new method to quantify environment in simulations: MPIA Heidelberg (Nov 2020)
- Modelling the environmental dependency of galaxy evolution: University of Groningen (Nov 2020)
- Beyond the halo boundary: Properties of galaxies in the infall regions: Garching (Oct 2020)
- Galaxy evolution in L-Galaxies and IllustrisTNG: MPIA Heidelberg (Oct 2020)
- Modeling the environmental dependency of galaxy evolution in simulations: AIFA Bonn (Oct 2020)
- The role of environment in galaxy evolution: AIP Potsdam (Sep 2020)
- Distribution of baryons inside and around haloes: 9th IMPRS symposium, MPE (July 2020)
- A method to quantify environment and model ram-pressure stripping: EAS meeting (Jun 2020)
- L-Galaxies vs. IllustrisTNG simulations: University of Southampton (Jun 2020)
- The role of environment in galaxy formation and evolution: MPA (Apr 2020)
- Comparing galaxy formation in the L-Galaxies semi-analytical model and the IllustrisTNG simulations: Virgo meeting Durham (Jan 2020)
- Removing the artificial halo boundary: MPA Cosmology Seminar (Oct 2019)
- No Place for the Halo Boundary: CosmoGold Conference IAP, Paris (Jun 2019)
- Local Background Environment of galaxies: 6th IMPRS Students Symposium, MPE (Apr 2018)
- Markovianity in Structure Formation: Cosmology Conference, IASBS, Zanjan, Iran (Feb 2017)
- Structure Formation as a Stochastic Process: Sharif University of Technology (Sep 2016)
- Halo Merger Trees and Bias: Sharif University of Technology (Jan 2016)
- Excursion Set Theory (EST): Sharif University of Technology (Aug 2015)

Conferences, Meetings, and Workshops

- EAS meeting, Krakow (Jul 2023)
- Multiphase gas conference, Kochel am See (Jun 2023)
- LEM Meeting, CfA, Massachusetts (remote, Mar 2023)
- HERA workshop, ORIGINS Garching (Feb-Mar 2023)
- MMC conference, ESO Garching (Dec 2022)
- L-Galaxies workshop, Hertfordshire-London (Nov 2022)
- ISSI Meeting, Bern (Oct 2022)
- L-Galaxies meeting, Munich (July 2022)
- Virgo Meeting, Munich (July 2022)
- Galaxy Clusters, Virtual (Apr 2022)
- KooGiG Conference, Peking - Virtual (Nov 2021)
- Ringberg Meeting MPA, Tegernsee (July/Aug 2021)
- Virgo Meeting (Virtual, Jan 2021)
- Quenching cluster galaxies in the cosmic middle ages (EAS virtual, Jul 2020)
- Advanced Course (Workshop): Galaxy formation and evolution (MPE, Mar 2020)
- Virgo Meeting (Durham, Jan 2020)
- Advanced Course (Workshop): Structure formation (MPE, Nov 2019)
- Dynamics of Large Scale Structure Meeting (MIAPP, Jul 2019)
- CosmoGold Conference (IAP Paris, June 2019)
- Advanced Course (Workshop): Galaxy evolution (MPE, April 2019)
- Advanced Course (Workshop): Astrophysics of Black Holes (MPE, Feb 2019)
- Python for HPC workshop (MPCDF, Nov 2018)
- IllustrisTNG workshop (MPA, Oct 2018)
- ICM conference (ESO Garching, Oct 2018)
- Advanced Course (Workshop): Large Scale Structure of the Universe (MPE, Jul 2018)
- Large Scale Structure Summer School (Berlin, Jul 2018)
- Advanced Course (Workshop): Database fundamentals (MPE, Jun 2018)
- Advanced Course (Workshop): AGN Physics (MPE, Mar 2018)
- Black holes workshop (Saas-Fee, Jan-Feb 2018)
- Virgo Meeting (MPA, Dec 2017)
- Advanced Course (Workshop): High Energy Processes (MPE, Oct 2017)
- Semi Analytic Models Workshop (Munich, Jul 2017)
- National Conference on Cosmology (IASBS Zanjan, Feb 2017)
- International Meeting on Modified Gravity (IPM Tehran, Jan 2016)

Awards and Honours

- Received the prestigious **Ernst Patzer** Prize for the best paper in **2023** for my publication: *Feedback Reshapes Baryon Distribution Within Haloes, in Halo Outskirts, and Beyond: The Closure Radius from Dwarfs to Massive Clusters*

- Received a fully-funded IMPRS PhD position (2017)
- M.Sc. Thesis **ranked 1st** in the Physics Department of Sharif University of Technology (2016)
- **Ranked in the Top 10** in Iran's national master's in physics entrance exam out of ∼**8000** participants (2014)

Reviewing and Organizing Experiences

- Reviewed several papers for high-impact scientific journals such as Monthly Notices of the Royal Astronomical Society (MNRAS) and The Astrophysical Journal (ApJ)
- Co-organized the 2022 Girls' Day at Heidelberg University
- Organized bi-weekly theoretical galaxy formation meetings at MPA, Munich (2021-2022)

Student Supervision

- Akash Vani - PhD, MPA, 2022-, co-advised with Profs. Guinevere Kauffmann and Volker Springel
  - *Project: Scaling relations in the L-Galaxies model and comparison with observations*
- Finlay Taylor - M.Sc. student, Heidelberg University, 2023, co-advised with Dr. Dylan Nelson
  - *Project: Discovering the impact of supermassive black hole feedback on low-mass galaxies*
- Milan Staffehl- M.Sc., Heidelberg University, 2023-2024, co-advised with Dr. Dylan Nelson
  - *Project: Exploring the origin of the cold gas in galaxy clusters and galaxy groups*
- Emmanouela Gerakaki, B.Sc., Heidelberg University, 2023-2024, co-advised with Dr. Dylan Nelson
  - *Project: The complexity of galaxy evolution in the cosmic web*

Computational Skills

- **Programming Languages -** Proficiencies and Descriptions:
  - **C/C++:** Advanced. Key contributions:
    - The Arepo Code: Designed and implemented a new sophisticated black hole feedback model based on mass, accretion rate, and spin
    - L-Galaxies Model: Implemented novel gas stripping method, modified MCMC mode for model calibration, and introduced new gas to halo infall recipe (Ayromlou et al. 2021b).
    - The LBE code: Developed from scratch to compute local background environment (LBE) properties of galaxies/subhaloes using simulation particle data. Applied to the Millennium (I, II) and IllustrisTNG simulations (Ayromlou et al. 2019).
    - The GADGET4 Code: Implemented the LBE gas stripping method in the GADGET version of the L-Galaxies semi-analytical model
  - **Python:** Advanced. Preferred language for data analysis and visualization.
  - **Matlab, R, IDL, Mathematica:** Intermediate/Familiar.
- **General Computer Skills**:
  Office, Latex, Windows, Linux, Git, SLURM, Photoshop (and GIMP), Web-Designing

Languages

Persian (Native), English (Full professional proficiency), German (Intermediate)

Academic References

- **Prof. Dr. Guinevere Kauffmann**
  (PhD supervisor, Scientific Director at the Max Planck Institute for Astrophysics)
  - Webpage: http://www.mpa-garching.mpg.de/galaxyformation
  - Email: gamk@mpa-garching.mpg.de
- **Prof. Dr. Simon D. M. White**
  (PhD supervisor, Emeritus Scientific Director at the Max Planck Institute for Astrophysics)
  - Webpage: https://wwwmpa.mpa-garching.mpg.de/∼swhite/
  - Email: swhite@mpa-garching.mpg.de
- **Dr. Dylan Nelson**
  (Postdoctoral mentor, Research Group Leader at the Center for Astronomy of Heidelberg University)
  - Webpage: https://www.ita.uni-heidelberg.de/∼dnelson/
  - Email: dnelson@uni-heidelberg.de
- **Dr. Annalisa Pillepich**
  (Collaborator, Research Group Leader at the Max-Planck-Institute for Astronomy, Heidelberg)
  - Webpage: https://www.mpia.de/gc-theory
  - Email: pillepich@mpia-hd.mpg.de

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See www.ayromlou.com for more info.