Probing cosmic monsters: confronting hydrodynamic simulations with new observations of high-density environments

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Publications

Refereed publications

1. *How to Interpret Measurements of Diffuse Light in Stacked Observations of Groups and Clusters of Galaxies*
   Ahad, S. L., Bahé, Y. M., Hoekstra, H., 2023, MNRAS, 518, 3685.

2. *Ultra-Diffuse galaxies in the MATLAS low-to-moderate density fields*
   Marleau, F. R., Habas, R., Poulain, M., Duc, P.-A., Müller, O., Lim, S., Durrell, Durrell, P. R., Sánchez-Janssen, R., Paudel, S., **Ahad, S. L.**, Chougule, A., Bílek, Bílek, M., Fensch, J., 2021, A&A, 654, A105.

3. *Structure and morphology of the MATLAS dwarf galaxies and their central nuclei*
   Poulain, M., Marleau, F. R., Habas, R., Duc, P.-A., Sánchez-Janssen, R., Durrell, P. R., Paudel, S., **Ahad, S. L.**, Chougule, A., Müller, O., Lim, S., Bílek, M., Fensch, J., 2021, MNRAS, 506, 5494.

4. *The stellar mass function and evolution of the density profile of galaxy clusters from the Hydrangea simulations at* $0 < z < 1.5$
   Ahad, S. L., Bahé, Y. M., Hoekstra, H., van der Burg, R. F. J., Muzzin, A., 2021, MNRAS, 504, 1999.

Submitted/To be submitted

1. *An environment-dependent halo mass function as a driver for the early quenching of* $z \geq 1.5$ *cluster galaxies*
   Ahad, S. L., Muzzin, A., Bahé, Y. M., Hoekstra, H., 2023, submitted to MNRAS

2. *Preparing for low surface brightness science with the Vera C. Rubin Observatory: A Comparison of Observable and Simulated Quantities*
   Brough, S., **Ahad, S. L.**, Bahé, Y. M., Ellien, A., Gonzalez, A. H., Jiménez-Teja, Y., Kimmig, L. C., Martin, G., Martínez-Lombilla, C., Montes, M., Pillepich, A., Ragusa, R., Remus, R.-S., Collins, C. A., Knapen, J. H., Mihos, J. C., 2023, submitted to MNRAS

3. *The Intragroup Light in KiDS+GAMA Groups*
   Ahad, S. L., Hoekstra, H., Bahé, Y. M., 2023, in preparation

Curriculum Vitae

I was born in Madaripur, a small town near Dhaka, Bangladesh, in 1992. Like most children, I loved listening to stories, especially stories of adventure, fairy tales, and discoveries. This, paired with the inspiration from my mother, who was a high school teacher of Chemistry and told me stories of all the fun things science can do, made me decide what I wanted to do when I grew up - travel the world and be a scientist! I suppose I never grew out of this wish, although my fascination for astronomy only became strong enough for me to pursue it much later.

I was always curious about how and why things happen, making my academic journey quite a fun experience. After finishing middle school in Madaripur, I moved to Dhaka for a better high school experience than what my hometown could offer. Right before starting high school, I got interested in astronomy after reading a book about how our understanding of the Universe changed with the last few centuries of work in physics and cosmology. Around the same time, I saw a newspaper advertisement for the National Astronomy Olympiad that was going to happen in a few months. I collected the few available books back then in Bengali on introductory astronomy and stargazing to prepare for the Olympiad. I surprisingly became the regional champion that year, and, not so surprisingly, did quite poorly in the national one. This experience made me excited to learn more about physics and astronomy.

However, there was no scope for studying astronomy in Bangladesh. Going abroad right after high school was not an option for me, especially to study astronomy, because it also had no future as a career option back home. So, after finishing high school, I sat for the university admission tests in Bangladesh and got selected for all the best options in the country. While my family wanted me to pursue medical school like most of my cousins, I opted for Electrical and Electronic Engineering, thinking that learning about electronics and robotics would be fun. But with the ulterior motive that I may be able to switch to astronomy in graduate school. Meanwhile, between finishing high school and starting my undergraduate, I again participated in the Astronomy Olympiad, became the national runner-up, and participated in the

10th International Olympiad of Astronomy and Astrophysics in Beijing, China as the first female participant from Bangladesh. Exploring problems in astronomy with participants from around the world in those ten or so days was the best experience of my life back then, and this experience made it clear that what I wanted to do in the long run was astronomy indeed.

My undergraduate thesis was in optoelectronics, on designing and simulating performances of optoelectronic biosensors with Prof. dr. Md. Zahurul Islam. I learned about the research process during this time and greatly enjoyed the experience. After graduation, I applied for astronomy master programs and was thrilled to get accepted for the two-year Erasmus Mundus Joint Master Degree program (AstroMundus) with a scholarship. Throughout the program, I studied at the University of Innsbruck in Austria, the University of Padova in Italy, and the University of Belgrade in Serbia. Apart from the mandatory and additional (optional) courses, I worked on short projects on different topics of interest, from asteroseismology and stellar evolution to studying the active galactic nuclei from SDSS archival data. During the second semester, I attended the MPIA summer school in Heidelberg on compact objects and gravitational waves. During these explorations, I realized that I enjoyed studying the multi-scale and big-picture aspect of extragalactic astronomy the most, and decided to work on characterising the nucleated dwarf galaxies from the MATLAS survey at the University of Innsbruck with Prof. dr. Francine Marleau for my master's thesis.

I started my PhD at Leiden Observatory under the supervision of Prof. dr. Henk Hoekstra and Dr. Yannick Bahé in October 2018. My research was at the interface of simulations and observations, where I studied different aspects of galaxy evolution in galaxy groups and clusters. My work primarily focused on developing systems to carefully compare simulations and observations to facilitate improved insights from the next generations of simulations and observations. Despite the pause during the pandemic, I was fortunate to attend summer and winter schools and present my work in different workshops and conferences. The interactions from these experiences have been very inspiring and stimulating in shaping my research direction.

During my PhD, I worked as a Teaching Assistant for the Numerical Recipes course (Master) and the Galaxies and Cosmology course (Bachelor). I also had the pleasure to co-supervise two master students in their research projects. I was also a part of the EDI and Sustainability committees of the observatory from 2021 until 2023. Apart from research, astronomy and science outreach is something I deeply care about. In the absence of academic astronomy, outreach programs gave me the opportunity to pursue this fascinating field as a career, and I have been actively

connected to astronomy outreach for over a decade. During my undergraduate years, I co-authored an introductory astronomy book for high school students in my native language, Bengali. In Leiden, I helped organise Astronomy on Tap from 2019 to 2022. I have also given many in-person and remote talks on introductory astronomy and galaxy evolution for Bangladeshi audiences ranging from middle school to university graduates.

I will join the Waterloo Centre for Astrophysics (WCA) in December 2023 as a WCA Postdoctoral Fellow. In the next three years, I am excited to study galaxy quenching in high redshift clusters and protoclusters, and perform statistical analysis of intragroup and intracluster light from Euclid and LSST data.

Acknowledgements

My PhD journey has been challenging and transformational in many ways, and approaching the finish line has been possible thanks to the remarkable and kind people who helped along the way.

First, I want to express my deepest gratitude to my supervisors, Henk Hoekstra and Yannick Bahé. Thank you for giving me the opportunity and freedom to follow my curiosity through the PhD projects. I am very grateful for sharing your insights that helped me improve my understanding of astronomy, academia, science, outreach, and more. I look up to your passion for science and pursuit of excellence, and how you guided me with kindness and patience throughout difficult times is what I want to internalize the most in my future career. I hope our paths will cross again in future and allow me to further learn from your wisdom. Also, I am grateful for the kind guidance of Adam Muzzin through several of my PhD projects. I have learned a lot from you and thoroughly enjoyed our discussions about exciting science. I look forward to more opportunities to work together in future!

I want to thank the past and current admin and support staff of the Observatory - Evelijn, Marjan, Monica, Alexandra, Robin, Nancy, Somayeh, Châtelaine, Alina, Hafize, and others for their constant support from the beginning till the end of my PhD experience. I am incredibly grateful for the support from the SCIS team with the residence permit, and the IT Helpdesk team, especially during the 'work from home' era. Also, I want to thank the Graduate School Office staff for their support throughout. All of your efforts not only kept things going smoothly but also helped me stay sane whenever things went wrong.

I would also like to thank the observatory social committee for keeping up the social and fun energy at the institute. The yearly social events are some of the best memories I have of my time here. Also, I highly appreciate the information and support the Observatory Wellbeing committee provided through the difficult pandemic and post-pandemic era.

I extend my thanks to the past and present members of the weak lensing and cos-

mology group, for all the nice interactions and engaging science discussions these past years. I have learnt a lot from all of you about science and collaboration. Stefan and Cas, being your daily supervisor have been a pleasure and a great learning opportunity that only comes through mentoring. Thank you for your dedication and enthusiasm during the projects. I am also thankful to other staff members of the Observatory with whom I had interactions on different occasions. Koen, Matthieu, Jackie, Marcel, Leonard, Violette, Aurora, Xander - thank you very much for the pleasant interactions and your support and care for the students.

My thanks to the Astronomy on Tap Leiden organising team for the welcoming and fun work environment. Francisca, Wendy, Alex, Alex, Anniek, Aida, Stella, Marta, Andrés, Zuzanna, Michelle, and everyone else - it was a great pleasure to be a part of the team. I also thank the members of the EDI and Sustainability committees of the observatory. I surely learned way more than I could contribute as a part of these two committees, and I owe every one of the committee members for my personal journey towards promoting more inclusive and sustainable practices in the scientific community and the broader society in general.

I want to thank my collaborators from the LSST low-surface-brightness working group and the ISSI protocluster research group for the opportunity to be a part of such engaging and supportive teams. I hope to continue our collaboration in future.

A big part of my PhD went in a fast-forward mode because of the pandemic and some additional personal challenges. However, I have been lucky to meet many incredible people in the PhD cohort and made great friends. Our first-year PhD retreat at Duinrell is a very dear memory (thanks to the observatory for organizing the introductory event!), and so was the end-of-first-year trip around the Hoge Veluwe park (Thanks a lot to Marina and Lýdia for organizing this!). My thanks to the PhD candidates who started before our 2018 cohort for being incredibly kind and welcoming. Kim, thank you for all the nice lunch times, and for listening to my venting when I was overwhelmed. Kim, Pedro, Yapeng, Niccolò, Amy, and Christian - it was a pleasure sharing the office with you at different times. Marina, one of the few good things that happened to me during the pandemic was your friendship! Your courage and kindness always inspire me. Thank you and Folkert for all the long conversations (including ranting about work of course), fun tours, art sessions, board game bonanzas, and wonderful meals we had together. Lýdia, I greatly admire your resilience. Thank you for always reaching out, for the honest conversations, and for being a great friend. Sanjana, thank you for all the nice memories - especially for letting me play with Akupara. I always enjoyed our conversations about travelling, food, and whatnot.

Anna and Mantas - it was a joy having you two as office neighbours! Nastasha, thank you very much for your help during my job application time! Thanks to all the PhDs, postdocs, and master students of the Observatory who made the past five years in Leiden an engaging, and enjoyable experience - Maria Cristina, Christos, Andrej, Jit, Gabriella, Omar, Danna, Valeriya, Tomasso, Eleonora, Santiago, Olivier, Martijn, Martijn, Stijn, Turgay, Shun-Sheng, Jeger, Dirk, Xiaoyuan, Sander, Shravya, Jeroen, Rens, Naadiyah, Sarah, Ashley, Willeke, Dora, Zephyr, Luna, Dario, Alessandro, MJ, Pooneh, Roland, Chloe, Erik, Evgenii, Roi, Zorry, Andrés, Joey, Fraser, Dilovan, Bas, Kirsty, Hiddo, Pranjal, Morgan, Katie, Brian, Wil, Xuechen, Zhenlin, Patrick, Danial, Alex, and everyone else I had the pleasure to interact with.

My biggest thanks to my husband Ruslan, my family in Bangladesh and my family-in-law from Ukraine for being constant sources of support and strength during my PhD journey, even when they themselves were going through very challenging times. Ruslan, I can never express my gratitude enough for all your support throughout these years, all on top of working on your PhD yourself. Thank you for all the packed lunches, the discussions about work whenever I needed to think out loud, and for restoring my belief in my capacity to finish the work whenever I felt lost. I am grateful for all the ups and downs we have been through together across Europe, and I am excited to see what awaits us in Canada!

I want to thank my undergraduate besties — Manira, Maitraye, Sunandita, who are more like sisters and have been the best work-from-home buddies and support system whenever I needed. It was curious how the pandemic made our PhD journeys way more connected than it would have been otherwise. I cannot wait to finally live closer to you girls and hopefully meet more than once every five years!

Last but not least, I want to thank my mentors from Bangladesh. As there is still no way to pursue astronomy as a career there, the path I walked is a rarely chosen one. I am grateful to Mrityunjoy Saha, Asrafuzzaman Akhunji, Farseem Mannan Mohammedy, Md. Zahurul Islam, Arshad Momen, and Munir Hasan, who supported and encouraged me on my journey to pursue astronomy. Also, my thanks to the astronomers from Bangladesh who showed that this is possible and shared their experiences whenever I asked for direction - Sultana N. Nahar, Khan Md. Bin Asad, and Syed Ashraf Uddin.