Research report, Ricarda Beckmann, Easter 2022

This report covers the timeframe from May 2021 to April 2022

Research projects

My research explores the co-evolution between supermassive black holes and their host galaxies across cosmic time. Every massive galaxy hosts a supermassive black hole in their centre whose properties show a remarkably strong correlation with that of their host galaxy. This strongly suggests that black holes evolve differently in different galaxies, but also that the galaxies are influenced by their black holes over time. My research probes both of these aspects of black holes in galaxies, with some projects more focused on the evolution of black holes itself, while others are more focused on how black holes influence their environment.

Galaxy clusters

Galaxy clusters are accumulations of tens to thousands of galaxies. The space between these galaxies is filled with hot gas, which is thought to be strongly influenced by the jet driven by the supermassive black hole in the cluster's central galaxy. How this gas evolves over long periods of time is a topic I have been working on for several years. This year, I submitted two first-author publications on the subject. I am also working with a young postdoc in France on a new project in this area, and a group of observational astronomers in the US and China to compare simulations to observations in this field.

The fist supermassive black holes

One of the key scientific questions in astrophysics today is the origin of the first supermassive black holes. These objects are frequently seen in observations, but the rapid growth required to make these extreme objects challenges our understanding of how they could have come to be. For this fellowship, I am working on unravelling the mysteries surrounding these objects. This project is ongoing. Good progress has been made, and a publication on the origin of the first supermassive black holes is in preparation.

Small-scale gas dynamics

Large-scale astrophysical simulations of the type I usually use in my work are useful to understand the evolution of astrophysical objects such as whole galaxies or galaxy clusters. However, due to their computational cost, they necessarily have limited resolution and therefore often fail to predict phenomena on small scales. To study these, I have executed several projects in conjunction with PhD and Part III students that specifically focus on individual small-scale phenomena too understand how individual gas clouds in galaxy clusters evolve over long periods of time, or how the gas in and around black holes slows them down. Two publications in this area are submitted and currently under review.

Working with students & Teaching

Part III project

This year, I worked in conjunction with Dr. Anastasia Fialkov, and Part III student Edmund Ross, to see how stars disrupted by supermassive black holes (so called tidal disruption events), can be used to learn more about the nature of dark matter in the early Universe. The project yielded interesting early results that laid the groundwork for a future scientific project in this area.

Conferences & Talk

1. 2021/07 - National astronomy meeting - contributed talk

2. 2021/09 - Ramses User Meeting 2021 - contributed conference talk
3. 2022/02 - University of Oxford - invited colloquium
4. 2022/03 - University of Bath - invited colloquium
5. 2022/04 - Breakthroughs in Numerical galaxy evolution - invited conference talk
6. 2022/04 - LYRICS meeting 2022 - invited talk
7. 2022/04 - Institut d'Astrophysique de Paris - invited talk

Outreach

- 2022/03 - "NewScientist Instant Expert: Frontiers of cosmology", London - invited talk

Funding & Resources

One of the main requirements for my research is adequate access on supercomputers, which are obtained by applying for a certain number of usage hours to national computing centres during open calls. Proposals are commonly submitted by groups of researchers, led by a senior academic. In the last six months I contributed projects to both British and French resources on proposals lead by Prof Debora Sijacki in Cambridge and by Dr Yohan Dubois at the Institute d'Astrophysique de Paris. My contributions were awarded their resources on both proposals, so I am now well supplied with the resources I need to conduct my research. I have also submitted several grant applications to national and international funding bodies that will hopefully support my research in years to come. The evaluation process is ongoing.

Publications submitted since April 2021

1. Volonteri M., Pfister H., Beckmann R., Dotti M., Dubois Y., Massonneau W., Musoke G., et al., "Dual AGN in the Horizon-AGN simulation and their link to galaxy and massive black hole mergers, with an excursus on multiple AGN" 2021, arXiv, arXiv:2112.07193
2. Olivares V., Salome P., Hamer S.L., Combes F., Gaspari M., Kolokythas K., O'Sullivan E., et al., "Gas condensation in Brightest Group Galaxies unveiled with MUSE" 2022, arXiv, arXiv:2201.07838
3. Massonneau W., Volonteri M., Dubois Y., Beckmann R.S., "How the super-Eddington regime regulates black hole growth in high-redshift galaxies" 2022, arXiv, arXiv:2201.08766
4. Beckmann R.S., Dubois Y., Pellisier A., Olivares V., Polles F.L., Hahn O., Guillard P., et al., "Cosmic rays and thermal instability in self-regulating cooling flows of massive galaxy clusters" 2022, arXiv, arXiv:2204.03629
5. Beckmann R.S., Dubois Y., Pellisier A., Polles F.,Olivares V., "AGN jets do not prevent the saturation of conduction by the heat buoyancy instability in simulated galaxy clusters" 2022 arXiv, arXiv:2204.12514