

# Research report, Ricarda Beckmann, Easter 2021

This report covers the timeframe from the start of my fellowship, November 2020, to May 2021.

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## Research projects

My research in general explores the co-evolution between supermassive black holes and their host galaxy. As far as we can know, every massive galaxy hosts a supermassive black hole in their centre. Not only do these black holes exist in galaxies, but their properties show a remarkably strong correlation with that of their host galaxy which strongly suggests that black holes evolve differently in different galaxies, but also that the galaxy itself is influenced by its black hole 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**

The topic of how gas in galaxy clusters evolves under the influence of the jets driven by the supermassive black hole in the central cluster galaxy is a topic I have been working on for several years, with some projects ongoing. This project uses a suite of simulations of galaxy clusters with different parameters to explore which physical processes dominate the evolution of cooling, and the resulting dense, cold gas, in galaxy clusters. A first-author publication from this work is in progress.

### **The first supermassive black holes**

One of the main open questions on my field is the origin of the first supermassive black holes. These objects are frequently seen in observations, but hard to explain given our current understanding of supermassive black hole evolution. Given the limited timeframe available for their growth, they must have grown extremely quickly, and we do not yet understand the conditions that can lead to such rapid black hole growth. As part of this fellowship, I will use modern machine learning techniques in combination with powerful simulations to study the conditions that allow for rapid black hole growth in the early Universe. This project is in its initial stages but good progress has been made on the necessary software development.

### **Black holes in dwarf galaxies**

While the correlation between supermassive black holes and their massive host galaxies is well understood, black holes in smaller galaxies, so called dwarf galaxies, is much less well understood. In recent years, observations have started showing signs that many dwarf galaxies might contain so called intermediate mass black holes, which could be the missing link between the common stellar mass black holes we see in the Milky Way, and the supermassive ones observed in far-away galaxies. For this project I studied black holes in the NewHorizon simulation, a multi-national collaboration focused on studying galaxy evolution and its related fields using numerical simulations. As part of this work I contributed to the flagship publication of the collaboration (see below), and have a first-author publication in progress.

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## Working with students & Teaching

### **Part III project**

Even before the start of the fellowship I proposed a Part III project focused on studying the evolution of individual cold gas clumps being mixed with hot background gas over time. This project was a spin-out from my general work on galaxy clusters. I co-supervised this project with Prof. Debora Sijacki within the context of Part III Astrophysics projects. The research progressed. Very well and the student has successfully completed his project. We are planning for him to return to work with me as a summer student for a few months to turn the project into a publication.

## Supvisions

During lent term supervised 10 students for Part II Astrophysical fluid dynamics.

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## Conferences & Talk

1. 2020/11/06 - University of Toulouse - Invited Seminar
  2. 2022/11/11 - University of Cambridge - Seminar
  3. 2020/12/3 - SAZERAC conference - Contributed talk
  4. 2020/12/04 - Maynooth University - Invited Seminar
  5. 2021/01/22 - University of Cambridge - Seminar
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## Outreach

- “How astrophysicists use code to simulate the Universe | In conversation with Dr. Ricarda Beckmann” [<https://www.youtube.com/watch?v=rrTKwgScK7Q>]
  - “AoT London x Ricarda Beckmann — The mystery of the first supermassive black holes“ [<https://www.youtube.com/watch?v=61jbrE5bAdo>]
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## 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.

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## Publications since November 2020

1. Jackson, R.A. et al, The origin of low-surface-brightness galaxies in the dwarf regime, MNRAS, Volume 502, Issue 3, pp.4262-4276
2. Volonteri, M., Pfister, H., Beckmann R.S., et al, Black hole mergers from dwarf to massive galaxies with the NewHorizon and Horizon-AGN simulations , MNRAS, Volume 498, Issue 2, pp.2219-2238
3. Dubois, Y., Beckmann R.S., et al, Introducing the NewHorizon simulation: Galaxy properties with resolved internal dynamics across cosmic time ,accepted for publication in Astronomy & Astrophysics
4. Trebitsch, M. Et al, The Obelisk simulation: galaxies contribute more than AGN to HI reionization of protoclusters, accepted for publication in Astronomy & Astrophysics