

COMMISSION X1

CROSS-DIVISION COMMISSION X1

*Supermassive Black Holes, Feedback and Galaxy Evolution
Feedback and Galaxy Evolution*

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COMMISSION X1 Working Groups

Gravitational Lensing: new working group under consideration by our OC.

TRIENNIAL REPORT 2018-2021

1. Introduction

The primary rationale for Commission X1 is to foster the exploration of the physical processes that couple the growth of supermassive black holes (SMBH) to their host galaxies – the so-called feedback processes, that are key ingredients in galaxy evolution models, regulating their growth and also influencing their environments. The Commission’s motivation is strengthened by the rich observational capabilities that are now available and will become available in the coming years. In particular, detailed studies at high redshift will be possible with coming observatories, both on the ground (notably Vera Rubin Observatory, E-ELT, GMT, and TMT in the optical and infrared and JVL, SKA, GMRT, and LOFAR in the radio) as well as space missions (e.g., James Webb, Euclid, WFIRST, ATHENA).

2. Developments within the past triennium

Commission X1 has grown to 405 members with strong continued interest in its research topics – in particular galaxy evolution and SMBH feedback – which is illustrated by the ≈ 900 papers published per year on this topic over the last three years (from ADS: Astrophysics Data System at the Harvard-Smithsonian Center for Astrophysics). The Commission members also promoted, supported and contributed to a number of conferences. During 2019, relevant conferences to our Commission were:



Figure 1. Participants of the IAU Symp. 359, March 2020, Bento Gonalves, Brazil.

- Astrophysics of hot plasma in extended X-ray sources: June 12-14, Madrid, Spain
- Exploring the Energetic Universe: June 17-21, Artana, Kazakhstan
- Supermassive Black Holes: environment and evolution: June 19-22, Corfu, Greece
- Feedback and its role in galaxy formation: June 25-29, Spetses, Greece
- High energy phenomena in relativistic outflows: July 9-12, Barcelona, Spain
- A centenary of astrophysical jets: Observation, Theory, and Future Prospects: July 23-26, Manchester, UK
- Quasars in crisis: August 5-9, Edinburg, UK
- Active Galaxies and Quasars: September 9-10, Byurakan, Armenia
- The 3C Extragalactic Radio Sky: Legacy of the Third Cambridge Catalogue: September 16-20, Turin, Italy
- The Cosmic Baryon Cycle: Impact on Galaxy Evolution: September 19-21, Carlsbad, US
- IAU Symposium 356: Nuclear Activity in Galaxies Across Cosmic Time: October 7-11, Addis Ababa, Ethiopia
- Cosmic Evolution of Quasars: from the First Light to Local Relics: October 21-25, Beijing, China
- Twenty years of science with Chandra: December 3-6, Boston, US
- The Origins of Black Hole Mergers and Gravitational Waves: December 16-20, Lorentz Center, NL.

3. Symposium 359 - Galaxy Evolution and Feedback across different Environments

During 2019, one of the most important activities of the Commission was the organisation of the IAU Symposium 359 Galaxy Evolution and Feedback across Different

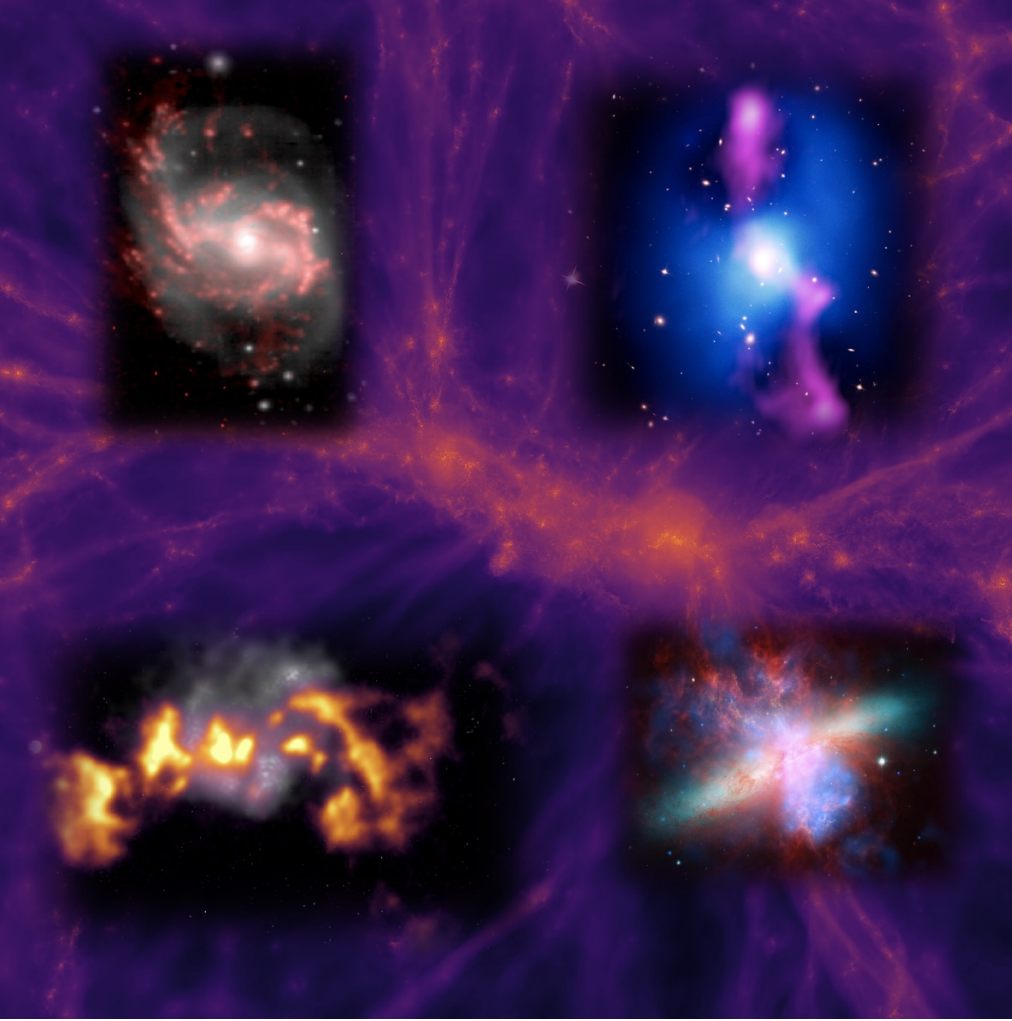


Figure 2. Cover illustration of the IAU Symp. 359, showing different forms of feedback affecting galaxy evolution: on a background of the cosmic web, clockwise from the top left: a Jellyfish galaxy, a radio-galaxy, a starburst galaxy and a quasar.

Environments. The Symposium took place in the town of Bento Gonalves, in the south of Brazil, from March 2 to 6, 2020. We attracted more than 180 participants from 23 countries (Fig. 1). The associated outreach and education activities involved about 2000 high school and younger students as well as people from the local community. In the Symposium, we had outstanding participation from approximately 80 students (mostly graduate, but also a number of undergraduate students), with the largest number from Brazil. The students participated not only in the Symposium but also in the Outreach and Education activities. During the rest of 2020, a large effort was dedicated to produce the scientific Proceedings volume (ISSN 1743-9213).

The cover illustration of the IAU S359 Proceedings (Fig. 2) portrays the topics of interest to our Commission, which were discussed at the Symposium. Beginning with the discussion of the cosmic web, through simulations by the Illustris-TNG collaboration, we investigated different forms of feedback. The Jellyfish galaxy shows the disturbance

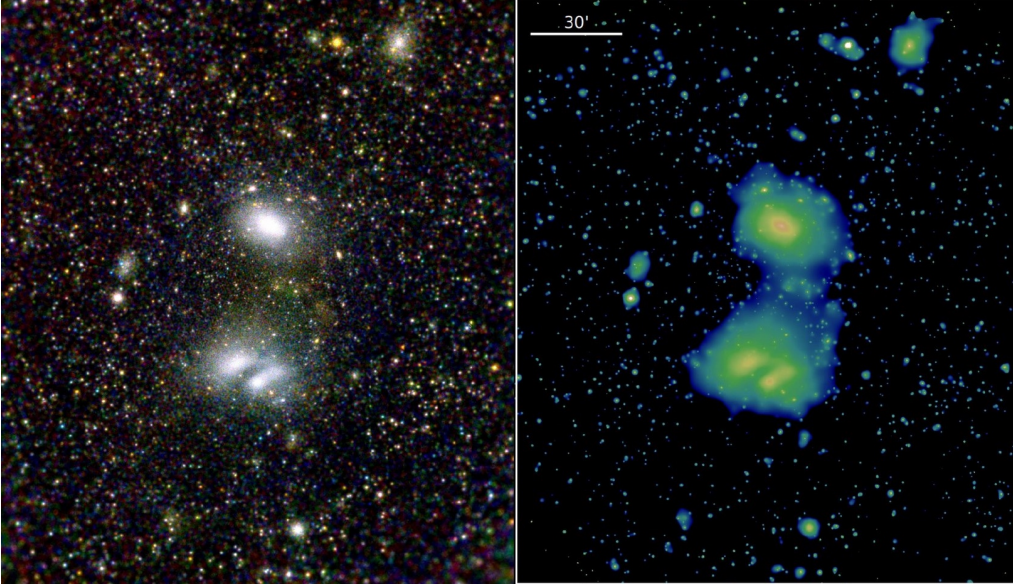


Figure 3. Image of the e-Rosita telescope showing two interacting galaxy clusters at 800 million light years.

produced by a cluster environment on its galaxies, while the radio galaxy, a cluster BCG, shows the feedback produced by its radio jets on the hot X-ray intracluster medium. The starburst galaxy shows the feedback produced by star formation and the quasar shows the power of the radiation due to energy liberated by mass accretion onto a nuclear SMBH. Many members of the Commission are doing forefront research on these topics.

4. Other on-going Initiatives

Recent and on-going initiatives of interest to the Commission include the Spectrum-Roentgen-Gamma mission that was successfully launched on July 13, 2019. Following an initial performance verification phase, it has begun its prime survey mission - eight complete surveys of the entire sky, one every six months, during 4 years. Based on the performance verification observations, in a survey of about 1/300 of the entire sky to the depth of the final survey, e-Rosita detected more than 15,000 AGN and more than 400 galaxy clusters (Fig. 3). This verified the pre-launch predictions that the completed survey will detect of order 100,000 galaxy clusters and more than four million AGN. The first six month all-sky survey has already resulted in a treasure trove of new X-ray detections, with about 1.1 million sources including more than 800,000 active galactic nuclei and more than 20,000 galaxy clusters (<https://www.mpe.mpg.de/7461950/erass1-presskit>).

Radio surveys in both the southern and northern hemispheres are well underway. In the radio regime, the LOFAR, GMRT, ASKAP-EMU surveys are providing remarkable insights into high energy processes and feedback by discovering all manner of new types of objects requiring detailed multi-wavelength followup. With the already operating facilities, and more to come, the exploration of Supermassive Black Holes, Feedback and Galaxy Evolution already is assured of exciting advances.

5. Closing remarks and Future Plans

The main goal of our X1 Cross-Division Commission on Supermassive Black Holes, Feedback and Galaxy Evolution is to promote the development of research on SMBHs, AGN (Active Galactic Nuclei) and star formation feedback and their role in galaxy evolution. With our commission, we aim at fostering interaction between theorists and observers from across the electromagnetic spectrum in order to investigate the interplay among the growth of SMBHs and evolution of galaxies, including the effects of the environment. We intend to bridge the studies on feedback from the "galaxy evolution community", that focuses mostly on star formation and galaxy evolution, and the "AGN community", which concentrates on feedback from SMBHs, in order to advance our understanding of galaxy evolution.

During the last 3 years we have transitioned the Commission homepage to the official IAU-maintained website and have initiated some participation in social media to give more visibility to the IAU science and in particular that of our Commission, including the advertisement of C.X1-related Symposia and Meetings.

Our plans for the next years include:

- Work as a forum for discussions about the best observational campaigns;
- Be a forum for discussion of particular objects or classes of objects to be observed along with needed multi-wavelength surveys;
- Propose and organise meetings, especially IAU Symposia;
- Be a forum of discussion about theory and simulations, supporting the dissemination of computing codes;
- Plan and coordinate sessions at IAU General Assemblies;
- Prepare a quarterly newsletter to announce meeting deadlines, key science advances, opportunities for collaboration, observing proposal deadlines.

Thaisa Storchi-Bergmann
President of the Commission

Christine Jones Forman
Vice-President of the Commission