Transactions IAU, Volume ????
Reports on Astronomy 2009-2012
???, ed.

DOI: 00.0000/X000000000000000X

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

None

TRIENNIAL REPORT 2015-2018

1. Introduction

The Commission was created following the Hawaii IAU General Assembly in 2015 as a cross-divisional commission between Divisions D and J. The primary rationale for the commission 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, that regulate the growth of the galaxies, and also influence galaxy environments. The motivation for the commissions is strengthened by the rich observational capabilities that are now available and are becoming available in the next few years. In particular, detailed studies at high redshift will be possible with future, more powerful observatories, both on the ground (notably LSST, E-ELT, GMT, and TMT in the optical and infrared and JVLA, SKA, GMRT, LOFAR in the radio) as well as space missions (e.g., James Webb, Euclid, WFIRST, ATHENA).

2. Developments within the past triennium

Feedback from AGN is observed as radio jets extending to hundreds of thousands of kpc, where their interaction with ambient gas produces X-ray emission. The formation of cavities and shocks is now seen in X-rays with Chandra in galaxies, groups, and clusters (e.g. NGC5044, NGC5846, NGC4636, Perseus and Phoenix Cluster), and their increasingly deep observations are enabling constraints on this type of feedback. Recent developments in the role of Supermassive Black Holes and their feedback in the evolution of galaxies include their formation and early feeding via streams from the cosmic web.

At somewhat lower redshifts, new findings include the so-called "compaction events" and the formation of "blue nuggets" at z 1-4, now also observed with ALMA. High and low-redshift surveys, including MaNGA and CALIFA, are now allowing a clearer scenario of the processes occurring on galaxy scales, while more detailed studies, performed with MUSE, SINFONI at the VLT and NIFS and GMOS IFUs at the Gemini Telescopes have been allowing the mapping the feeding and feedback mechanisms on tens to hundred of parsec scales. Theoretical models suggest that these are indeed the scales where fundamental processes, allowing the loss of angular momentum, occur. New catalogs from Swift, Chandra and XMM, have been fundamental to pinpoint AGN and provide a census of these sources that is independent of obscuration, besides providing maps of feedback in galaxy clusters. Unexpected large amounts of molecular gas have been seen with ALMA in many groups, where it has been concluded that they provide the necessary fuel for the growing SMBHs and the surrounding galaxy. ALMA is also revealing the first signatures of inflows in molecular gas in the inner kpc of galaxies, although more common being the outflows, which reach tens of solar masses per year in some sources. Initial studies from the short-lived Hitomi satellite provided insights into the effects of the cavities on hot atmospheres, suggesting the cavities could drive significant turbulent motions as part of the feedback process. Future observations are being planned by many groups using the new facilities soon to be available, notably LSST, E-ELT, GMT, and TMT in the optical and infrared, JVLA, SKA, GMRT in the radio, as well as space missions such as James Webb Space Telescope, Euclid, WFIRST, eRosita, XARM, and ATHENA. To review all these new developments and findings of the last few years, our commission has proposed a Symposium to take place in 2019, where the newest developments on the role of Supermassive Black Holes and their feedback in Galaxy Evolution will be reviewed.

At the 2015 IAU General Assembly in Hawaii (August 2015), an organizing/business meeting was held at the Hawaii Convention Center. Attendance was about thirty people. Discussions included possible roles and activities for the commission and means for communication with members.

One of the primary activities of the commission has been to review and support IAU Symposia and Focus Meetings. We have reviewed and supported eleven meetings that were relevant to Commission X1. In addition to supporting individual meetings, we reviewed and ranked the 35 meeting proposals submitted for 2017. While a prime goal of our review was to select the best proposals relevant to Commission X1, we balanced this goal with achieving overall balance for the selected meetings. In addition to support for meetings, we also supported new missions and facilities relevant to the commission.

In January 2018, we met with the IAU Paris office to discuss access to web pages. This led to plans for a Commission Web page to support activities related to the coming Vienna IAU meeting.

Since the inauguration of the *X1 Cross-Division Commission Supermassive Black Holes, Feedback and Galaxy Evolution*, membership has grown to 345 members.

3. Closing remarks and Future Plans

The goals of the X1 Cross-Division Commission Supermassive Black Holes, Feedback and Galaxy Evolution remain focused on supporting activities that promote the interaction between observational and theoretical astronomers including IAU-sponsored meetings and activities. The initial "startup" of the Commission was hampered by lack of

familiarity with capabilities and procedures. These are now greatly improved with better contact with the IAU offices. Future plans include:

- inauguration of the Commission web pages, maintenance of the web pages
- transition to the official IAU-maintained web site
- development of a newsletter highlighting material from the web pages,
- and planning and supporting future Symposia and meetings of interest to the Commission members
- another organizating/business meeting at the coming IAU Vienna meeting. At the meeting, we will discuss the possibility of establishing working groups targeted toward particular science goals, observatories, and new facilities.
- proposed Symposium to take place in 2019, where the newest developments on the role of Supermassive Black Holes and their feedback in Galaxy Evolution will be reviewed.

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