

# Growing Black Holes in COSMOS

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A workshop was held at IPMU between February 13-22 to pave the way forward to answer fundamental questions regarding the growth of supermassive black holes using the COSMOS survey such as those addressing the physical mechanism that triggers the growth of black holes, the epoch when the first black holes appeared, and whether a causal connection between the mass assembly of black holes and their host galaxies exists. The meeting was designed to span a broad range in topics related to active galactic nuclei (AGN), an observationally-defined class of objects in which mass is being converted into energy by a massive black hole sitting at center of practically every galaxy.

COSMOS is a unique extragalactic survey that covers two square degrees of the sky with observations by practically every observatory from both space (e.g. Hubble Space Telescope, Chandra X-ray Observatory) and the ground (e.g. Subaru Telescope, Very Large Telescope) to provide unprecedented coverage, of galaxies and their supermassive black holes, across the electromagnetic spectrum from radio to X-rays. In particular, the Subaru Telescope with Suprime-Cam, under the direction of Dr. Yoshiaki Taniguchi (Ehime University) has provided a suite of medium-band optical images thus contributing to a new era in precision photometric redshift estimates. Such an effort to utilize this vast array of telescopes requires the international cooperation of over one hundred dedicated scientists worldwide.

The workshop, attended by forty-one scientists, kicked off with a broad introduction by Dr. Luis Ho (Carnegie Observatories) and Dr. Martin Elvis (Harvard-Smithsonian Center for

Astrophysics) that covered what we know about black holes that power the low luminosity AGNs in the local Universe to the most luminous and distant quasars. Over the next two and a half days, there were contributed talks that addressed the physical properties of AGN including the circumnuclear dust content, the connection to star formation, and the relation to large-scale structures such as galaxy groups and clusters. An extensive discussion addressed the need to disentangle the emission from an AGN and its underlying host galaxy in order to assess the total (bolometric) energy output generated by supermassive black holes thus providing an accurate measure of the rate at which they grow in mass. Furthermore, one of the main goals of COSMOS is to trace the accretion of matter onto supermassive black holes over a wide range of cosmic time (i.e. the last 10 billion years).

The participation of scientists within the Japanese astronomical community was encouraged. For example, Dr. Toshihiro Kawaguchi (Tsukuba University) presented a new theoretical model of dust reprocessing of ultraviolet emission from AGN. Dr. Masayuki Akiyama (Tohoku University) reported on new results regarding the global evolution of the mass distribution of actively, growing supermassive black holes from the Subaru XMM Deep Survey. In addition, Dr. Tohru

Nagao (Kyoto University) kindly provided an overview of Japan's effort to carry out the next wide-area optical survey with Hyper-Suprime-Cam (HSC), a wide-field optical imager to be mounted on the Subaru Telescope this spring. Early science results from surveys with HSC are likely to make use of the multi-wavelength data available in COSMOS.

The final week of the meeting was dedicated to working group sessions that addressed ongoing observational efforts in COSMOS. There was much discussion and coordination of the near-infrared spectroscopic survey being carried out with FMOS on Subaru, a joint effort between IPMU and the University of Hawaii. These observations are enabling more accurate estimates of the masses of supermassive black holes at high redshift and unveiling the nature of AGN hidden by dust-obscuring clouds. There were also short presentations of new data sets in the near and far infrared with Hubble Space Telescope and Herschel. Finally, it was recognized that the Atacama Large Millimeter Array, with Japan playing a major role, opens remarkable opportunities to study supermassive black holes by detecting the reservoirs of cold gas that may be feeding these monsters.

The organizers and IPMU greatly appreciate the contribution from all of those in attendance at this workshop. We look forward to having you back again.

