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Black Hole Winds at All Scales

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Artistic representation of an active galactic nucleus winds
Credit: NASA/JPL-Caltech https://www.jpl.nasa.gov/images/pia18919-how-black-hole-winds-blow-artists-concept

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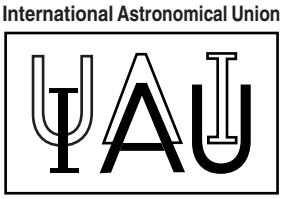

BLACK HOLE WINDS AT ALL SCALES

PROCEEDINGS OF THE 378th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HAIFA, ISRAEL 12–16 MARCH 2023

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Preface

Black holes are observed to drive powerful outflows on both stellar and galactic scales. The connection of the outflow to the accretion flow that feeds the black hole remains contentious. The physical launching mechanisms and astrophysical sites from which these outflows are launched also remain in debate; radiation, magneto-hydrodynamics, and thermal driving have all been proposed and modeled, with no consensual conclusion. Beyond their physics, the study of outflows is important for understanding how they affect their environment and host galaxy. The means by which outflows interact with their surroundings manifests itself in all wavelengths. Some examples of which are X-ray and UV ionized absorbers and obscurers, ultra-fast outflows at a fraction of the speed of light, massive molecular outflows, and extended radio emission. Despite significant progress in multi-wavelength observations, a coherent picture of black hole outflows has yet to emerge.

The goal of this IAU symposium was to better understand black hole winds by seeking common physical grounds for different outflows, in both stellar (X-ray binaries) and AGN (active galactic) black holes, in all wavelengths, and in the context of competing theoretical models. The connection of the winds to star formation, galactic feedback, and relativistic jets were discussed among observers, modelers, and theoreticians.

Seventy astrophysicists, both experts and students, convened for five full days at the Technion campus in Haifa. The exciting and popular topic brought together observers of many different wavebands, which made for a multitude of new data being presented and discussed. There was a good mix of low-energy and high-energy observations, including ground facilities and space observatories. Theoretical aspects of black hole outflows were also a big part of the discussions, and perhaps as expected, many puzzles about these winds remain.

In terms of new observations, IR astronomers presented JWST data indicating significant galactic feedback at redshifts above z = 6. New insights into the central sub-pc regions of active galaxies from GRAVITY were presented. In the mm-band, rich ALMA spectra covering a broad band provided new evidence that even the most obscured sources may host an accretion disk and produce outflows. Several new VLBA observations showed that even the radio quiet quasars host a compact, optically thick radio source at their core, while some of them also feature extended optically thin emission that can be associated with an outflow. In the UV with Hubble, broad absorption line systems allowed for quantitative estimates of mass outflow rates indicating that massive outflows in the most luminous quasars carry appreciable mass and energy out to kpc scales in the galaxy.

On the theoretical ground, a variety of simulations for magnetic and thermally driven winds were presented, some of which attempted to put galactic and stellar black hole winds on an equal footing. Cases from extreme mass accretion rates to advection dominated flows were covered. Topics of radiative driving and radiative transfer in outflows were discussed, a few of which even proposed comparisons with observations.

This volume collects contributions on the different themes discussed during the symposium, and in particular: the multi-wavelength picture of AGN outflows, spectroscopic methods, feedback on the host galaxy, outflows from stellar mass black holes, and theory & modelling of outflows.

Ehud Behar
Gabriele Bruni
(SOC co-chairs)

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