

DIVISION D

HIGH ENERGY PHENOMENA AND FUNDAMENTAL PHYSICS

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Gravitational Wave Astrophysics
Supermassive Black Holes, Feedback and Galaxy Evolution
Galaxy Spectral Energy Distributions

DIVISION D WORKING GROUPS

Div. D / WG

Supernovae

TRIENNIAL REPORT 2018-2021

1. Background

Division D deals with all astrophysical and astro-particle matters related to extreme physical conditions, mostly occurring in a special or general relativistic regime. It covers both theoretical and observational research and technological development, including implementation of ground-based experiments and space missions for high-energy astrophysics. In 2017, the already wide scope of Division D was enlarged with the advent of gravitational signals detections by the LIGO and Virgo interferometers, that involved the use of multi-wavelength observing facilities for electromagnetic follow-up and thus ushered the community to the era of "multi-messenger" astrophysics.

The acme of this approach was reached in August 2017, when the counterpart to gravitational radiation from a merger of a binary system of neutron stars was detected at all frequencies from gamma rays to radio. This identification proved the association of gamma-ray bursts belonging to the short-duration (or sub-second) group with binary neutron-star mergers and it confirmed the hypothesis that half of the elements heavier than iron in the Universe are synthesized during these coalescences via rapid neutron-capture process.

Besides representing a breakthrough in its own regard, this discovery fills an important gap in gamma-ray burst physics and specifically in our knowledge of their progenitors, as

the origin of long-duration gamma-ray bursts had already been assessed 20 years prior and known to be connected to the supernova explosion following the collapse of massive stellar cores (evolved from stars of more than $30 M_{\odot}$ in main sequence).

In the track of multi-messenger astronomy, in September 2017 a BL Lac object was identified as the source of PeV-energy neutrinos detected by ICECUBE, making it plausible that the relativistic outflows of BL Lac objects, and of blazars in general, can be efficient accelerators of very high energy cosmic rays. The mechanism whereby their central supermassive black holes transfer rotational energy to these powerful jets is not yet clear. The interferometric image at millimetric wavelengths of a black hole in the center of the giant elliptical galaxy M87 in the Virgo cluster, obtained by the Event Horizon Telescope collaboration, and the conferment of the 2020 Nobel Prize in Physics to Profs. R. Genzel, A. Ghez, and R. Penrose for their theoretical and experimental work on supermassive black holes demonstrate that the theme of black hole physics at all size scales, as well as the study of their close environments and host galaxies, is at the forefront of high-energy astrophysical research and ripe for success.

At the same time, the attention toward the astrophysical transients in general was enhanced by the advent of many large field-of-view facilities at all wavelengths, that can routinely detect tens to hundreds of variable sources per day (e.g. Fermi-LAT in gamma rays; eROSITA in X-rays; ZTF and various other optical high-cadence surveys; the CHIME radio-interferometer; LOFAR radio-frequency surveys). The field of time-domain astrophysics is thus close to its maturity, with many different classes of sources being now studied with much greater detail and sophistication than ever (e.g. supernovae of all types; fast radio bursts; blazar flares; magnetars), or being detected based on long-standing predictions (e.g. orphan afterglows). These upgrades will engender a significant progress in our knowledge of the inner workings of high-energy sources, their evolution and the tie-ins between classes of sources that are apparently disconnected.

2. Developments within the past triennium

2.1. *New IAU Members in Division D*

In the triennium 2018-2021 the IAU admitted the following new members, who became affiliated with Division D: Dr. G. Rezgui (IAU Junior Member), Profs. Man Ho Chan, R. Sacahui, A. De Angelis (IAU Associate Members). Moreover, Prof. Di Li (China), already an IAU Member affiliated with Divisions B,H,J, recently became affiliated also with Division D, to tighten the link with radio-astronomy.

2.2. *IAU Events sponsored by Division D*

Division D has regularly approved a number of IAU events, including Symposia both during and outside the 2021 GA, and Focus Meetings during the GA. However, Covid-19 notoriously determined a setback in their organization and running. Of those approved during the triennium under exam only IAUS 359 "Galaxy Evolution and Feedback Across Different Environments" (Bento Goncalves, Brazil, see Commission X1 Triennium 2018-2021 Report) could take place so far, being probably the last IAU Symposium that could be held in classical form, i.e. with the presence of most participants, before the worldwide ban on all meetings and conferences, dictated by the pandemic. The other Symposia are bound to be delayed or to take place in hybrid or fully online format. The proposals for 2022 GA and non-GA events are currently under review.

2.3. *IAU PhD Prize in Division D*

As it is customary, in January-February 2019 and 2020, the Steering Committee of Division D reviewed the material of 19 and 16 candidates for the IAU Division D PhD Prize 2018 and 2019, respectively. The winner of the 2018 Prize was Laura Becerra (Colombia) with the thesis: "Accretion in Compact Stars: Hypercritical Accretion in the Induced Gravitational Collapse and the Post-Merger Evolution of White Dwarfs"; the winner of the 2019 Prize was Guang Yang (USA) with the thesis "What drives the growth of black holes?". The review for the 2020 PhD Prize is underway. We have noticed the outstanding level of nearly all theses and the wide variety of topics they have addressed. They reflect the dynamism of research in the field of Division D.

2.4. *Commissions and Working Groups in Division D*

The three Commissions and the Working Group monitored by Division D (see previous page) submitted their reports for 2018-2021 and requested renewal for the next triennium.

3. Conclusion and future plans

This is a moment of tremendous boost in high-energy physics and astrophysics and the expectation is very high toward the clarification of outstanding problems and new breakthroughs into novel areas, like time-domain astronomy and multi-messenger astrophysics. Division D, with the assistance of its Commissions and Supernova Working Group, is poised to take these challenges and will stand at the forefront of research and innovation. All progress will be carefully documented in our regularly issued monthly Division D Newsletter.

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President of Division D

Isabelle Grenier
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