Research Highlight

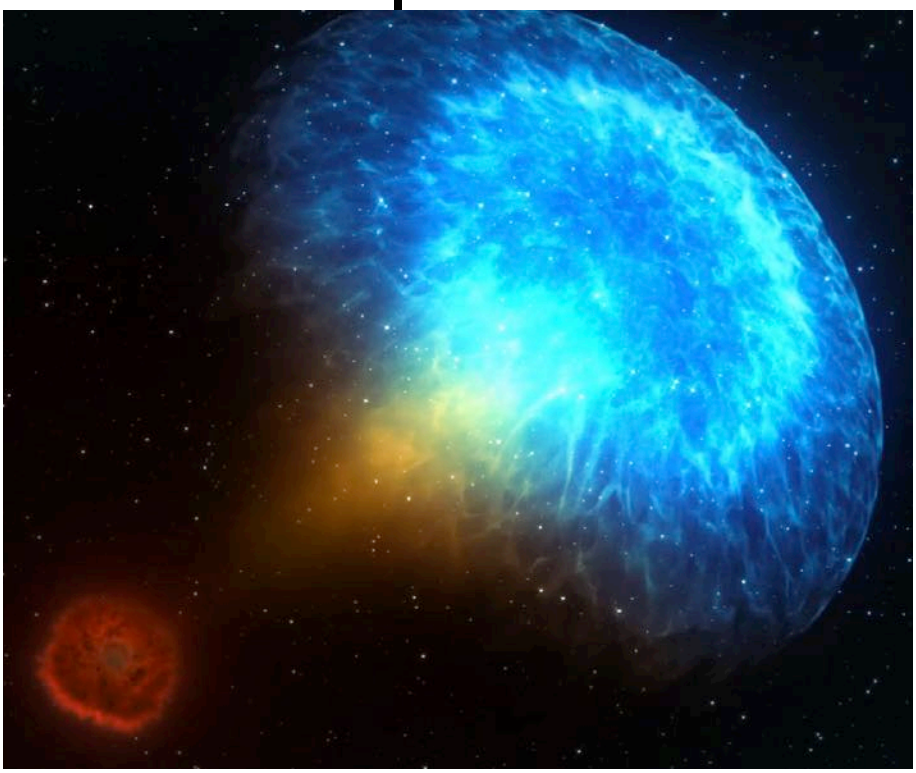
The Life, Death, and Afterlife of GW170817

Prof. Daryl Haggard *is an Assistant Professor of Physics at McGill University in the McGill Space Institute. She studies the Galactic centre and Sgr A*, electromagnetic counterparts to gravitational wave sources, accreting compact objects, supermassive black holes and their host galaxies, and multi-wavelength and time domain surveys. Dr.* **Melania Nynka** *is a MSI and Trottier Chair Postdoctoral Fellow at the MSI. Her primary research interests are in X-ray observations of neutron stars and the Galactic centre.* **Dr. John Ruan** *is a MSI and Trottier Chair Postdoctoral Fellow at the MSI. His research interests span from rapidly-growing supermassive black holes to observations gravitational waves.*

In Fall 2017, McGill Professor Daryl Haggard and MSI/Trottier Postdoctoral Fellows John Ruan and Melania Nynka contributed substantially to the discovery of the neutron star merger GW170817, which resulted in the first groundbreaking joint detection of a gravitational wave source and its electromagnetic counterpart. Together with the whole multi-messenger community, they recently marked the first anniversary of this exciting discovery, which has broad implications for astro-physics, cosmology, and fundamental physics.

GW170817 has garnered many firsts:

- The first gravitational waves detected from a neutron star (NS) binary,
- The first electromagnetic counterpart to a gravitational wave (GW) source,
- The first binary NS coalescence definitively associated with GWs and short gamma-ray bursts (GRBs),
- The first binary NS coalescence associated with a kilonova explosion,
- The first definitive proof that binary NS collisions produce elements heavier than iron, including gold, platinum, and uranium,
- The first collision to provide constraints on neutron star diameters and equations of state,
- The first standard siren measurement of the Hubble constant.



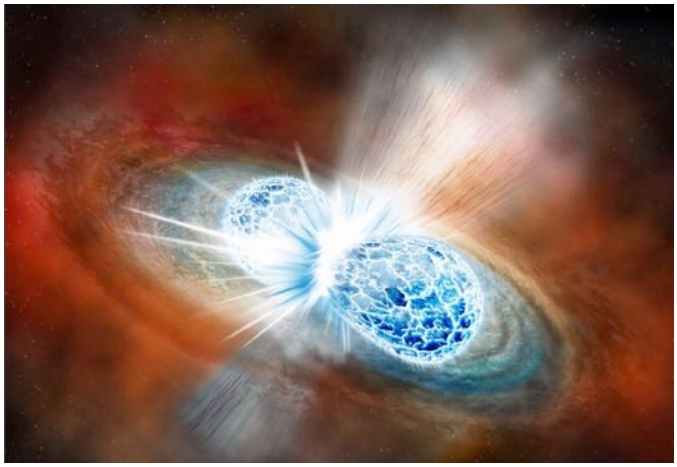
Left: Screenshot from an animation of the GW170817 outflow. (Image Credit: NASA Goddard Space Flight Center / CI Lab)

Many of these discoveries were made in the days and weeks immediately following the discovery, but the team at McGill has continued to study GW170817's energetic outflow at X-ray wavelengths over much longer time scales. GW170817's outflow, which current theories and observations indicate may be a quasi-spherical blast wave or a structured jet, continued to shine in the most recent Chandra X-ray Observatory observations collected in mid-August 2018, 358.6 days after detection of the merger. During summer 2018, McGill undergraduate students Hannah Dykaar and Marion Burnichon also joined the Haggard team to analyze X-ray observations of GW170817 from the XMM-Newton X-ray Observatory, which independently verified previous conclusions.

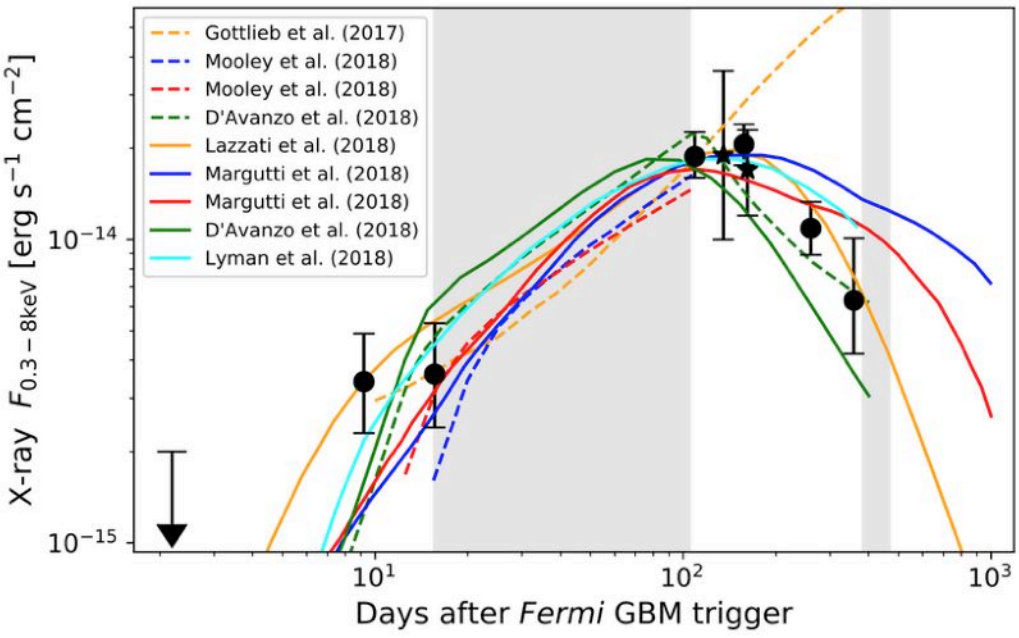
Haggard and her team are gearing up for another exciting season of discovery when LIGO-Virgo come back online in February 2019. Through multiple approved programs on space- and ground-based observatories, they will be chasing new neutron star collisions and hoping to detect the first neutron star-black hole merger. Stay tuned for another exciting year to come!

Why this is important

The discovery of GW170817 offered both the first gravitational waves detected from a neutron star binary and the first electromagnetic counterpart to a GW source. Our ongoing detection of an energetic outflow from this magnificent collision has challenged every model and brings new insight into the physics of neutron stars and short gamma-ray bursts.



Above: Artist's impression of the final moments of the neutron star merger, GW170817. (Image Credit: NASA)
Below: X-ray light curve of GW170817 from Chandra (black circles) and XMM (black stars), updated to include Chandra observations 358.6 days post-merger (Haggard et al. 2017, Ruan et al. 2018, Nynka et al. 2018). The colored lines show theoretical models for the outflow.



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