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Unforeseen Directions in Gravitational Wave Astrophysics

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Since the beginning of gravitational-wave discoveries in 2015, gravitational-wave and multi-messenger observations yielded a number of "surprises". We have detected more and heavier black holes than previously anticipated; multi-messenger emission from neutron star merger GW170817 showed structured high-energy outflow and produced a multi-component kilonova; additional messengers, such as heavy elements detected on Earth proved to add new information on cosmic processes. With the current publicly announced detection rate of about one per week, the latest observing period of Advanced LIGO, Virgo and KAGRA is poised to deliver additional surprises along with moving the field towards precision astrophysics. I will review several of the new interesting directions in gravitational-wave and multi-messenger observations that began only recently and promise to further enrich this field as the rate of detections will grow twentyfold in the next five years.