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The Gravitational-Wave Universe: Recent Results from LIGO-Virgo-KAGRA

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Ground-based gravitational-wave astronomy has entered an era of routine discovery. The LIGO-Virgo-KAGRA network completed its fourth observing run (O4) in November 2025, detecting roughly 250 new signals — more than doubling the total catalog from all previous runs. Binary black hole mergers are now detected nearly twice per week during operations, enabling population-level studies of compact object masses, spins, and merger rates. After briefly introducing gravitational waves and ground-based detectors, I will review recent results. Observational highlights include GW231123, whose ~225 solar-mass remnant sits in the intermediate-mass black hole regime and challenges stellar evolution models; GW250114, the loudest signal ever recorded, which enabled the first confident multi-mode ringdown test of the Kerr nature of black holes; and GW241011, characterized by rapid spin and an unequal mass ratio. Detecting the next multi-messenger event — a binary neutron star or neutron-star–black-hole merger accompanied by electromagnetic counterparts — remains an elusive priority for the field. I will explain how planned upgrades will more than double strain sensitivity, increasing detection rates by roughly an order of magnitude. The improved detectors will potentially reveal new source classes and serve as testbeds for Einstein Telescope and Cosmic Explorer technologies, all while opening rich opportunities for multi-messenger astronomy in the mid 2030s.

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