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Astrophysical observations and future projects of neutron stars and magnetars

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Neutron stars are enigmatic compact objects characterized by dense nuclear matter, rapid stellar rotation, and strong magnetic fields. Such an extreme environment has provided an accessible astrophysical laboratory to test fundamental physics. Recent astronomical observations from radio to gamma-rays have revealed a remarkable diversity of neutron stars: e.g., rotation-powered pulsars, accretion-powered pulsars, and magnetically-powered sources. Among important physical parameters of neutron stars, a wide range of magnetic field from 10^4 T to 10^{11} T is thought to be one principal cause of the diversity. Especially, enigmatic X-ray sources, Soft Gamma Repeater (SGRs) and Anomalous X-ray Pulsar (AXPs), are now considered to have extremely strong magnetic field reaching 10^{10}–10^{11} T, and thus, dubbed as "magnetars." They emerge mainly in the X-ray frequency with intense giant flares, short bursts, and X-ray outbursts. Unlike for rotation-powered or accretion-powered pulsars, the bulk of their X-ray emission appears to be powered by their super-strong magnetic fields. At this talk, I will review recent high energy astrophysical observations of strongly-magnetized neutron stars, and also overview approved future missions to approach the neutron star science, for example, Astro-H (launch in 2015) which realizes the high energy resolution and the Neutron star Interior Composition ExploreR Mission (NICER, launch in late 2016) mission which is dedicated to determine the equation of state of neutron stars.