Galactic Nuclei, Gravitational Wave Sources, and Their Electromagnetic Counterparts

1 Abstract

The historic detection of gravitational waves by the LIGO–Virgo Collaboration inaugurates a new era of doing astronomy and astrophysics. While new gravitational-wave sources will continue to be detected in the years to come, it is believed that more ground-breaking discoveries await the detection of electromagnetic counterparts, which in principle will help us pinpoint the location of gravitational-wave sources, elucidate their astrophysical origin (e.g., whether in the field or in star clusters), and possibly reveal new physics in the regime of strong gravity.

The aforementioned coincidence between gravitational-wave sources and electromagnetic radiation could be more easily produced in the innermost parsec of a galaxy, i.e., in an environment similar to the center of our Galaxy. This is partly because galactic nuclei are known to be a breeding ground of compact objects, such as white dwarfs, neutron stars, stellar-mass black holes, and supermassive black holes (more massive than 10^6 solar masses). Dynamical interaction and mergers of these compact objects will produce a wide spectrum of gravitational wave radiation, with frequencies extending across the sensitivity bands of different ground- and space-based detectors. Another reason is that the density of stars and gas is usually very high in a galactic nucleus, so that compact-object binaries are more likely to interact with baryonic matter and produce electromagnetic radiation.

The scientific goal of this project is to model and observe the electromagnetic counterparts to those gravitational-wave sources inside galactic nuclei. Potential topics include but are not limited to: (i) Event rate of different types of compact-object mergers in galactic nuclei, such as mergers of stellar-mass black holes or the inspiral of stellar-mass black holes into supermassive ones. (ii) Detection rate of these gravitational wave sources by LIGO/Virgo/LISA or the Chinese Taiji/Tianqin programs[1]. (iii) Interaction between gas and stars with gravitational-wave sources and the associated electromagnetic radiation. (iv) Propose observations or use archive data to search for electromagnetic counterparts. (v) Implications that can be derived from the Galactic Center, where both stellar-mass and supermassive black holes exist and data in multiple wavebands are available.

Both theorists and observers are encouraged to apply for this fellowship. Of particular interest are candidates with experience in (i) stellar dynamics of globular and nuclear star clusters, (ii) hydrodynamics of accretion disk and modeling its radiation, (iii) modeling

[1] http://www.nature.com/news/chinese-gravitational-wave-hunt-hits-crunch-time-1.19520

astronomical transients, such as supernovae, gamma-ray bursts, and tidal disruption events, and (iv) modeling and observation of dense star clusters. Applicants are also encouraged to relate their proposals with the current and upcoming facilities available in Chile and China, such as VLT, ALMA, LSST, CTA[2], FAST[3], Einstein Probe[4], and the Taiji or Tianqing programs.

2 Sponsors and Host Institutes

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3 Scientific Justification and Chile-China Connection

There are ambitious plans to build next-generation telescopes both in Chile and China. Most of these telescopes, in fact, are well suited for gravitational-wave astronomy. Exploring this common ground and identifying potential synergy between different telescopes could greatly increase the scientific payoff of each facility. The following are several possible approaches.

(i) The next breakthrough in gravitational-wave astronomy is finding in time domain an electromagnetic counterpart. For this purpose, the Large Synoptic Survey Telescope (LSST) to be built in Chile and the China-led Einstein Probe (EP), a satellite dedicated to X-ray transients, will both play crucial roles. These observations can be used to recover the spectral energy distribution, which is important for our understanding of the radiation mechanism (e.g. thermal or non-thermal).

(ii) Relativistic motion of matter around gravitational-wave sources usually produces shocks, which in the long run would manifest themselves by radiating infrared and radio emission (e.g. a supernova remnant). Detecting such radiation requires telescopes to have large aperture and high sensitivity, since the source is expected to be faint. The

[2] https://portal.cta-observatory.org
[3] http://fast.bao.ac.cn/en/
[4] http://ep.bao.ac.cn