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Chasing Gravitational Waves with the Cherenkov Telescope Array Observatory

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A complete view of gravitational wave (GW) events requires combining GW observations with broadband electromagnetic follow-up. In particular, TeV gamma rays, the most-energetic electromagnetic radiation currently associated with individual sources, will be crucial in understanding the acceleration processes and the environment near compact object mergers.

The current generation of Cherenkov telescopes, such as H.E.S.S., MAGIC, and VERITAS is actively searching for TeV emission associated with GW alerts through dedicated follow-up programs. Prospects for future observatories, such as the ASTRI mini-array and the Cherenkov Telescope Array Observatory (CTAO), are under evaluation.

We describe our approach for determining whether binary neutron star (BNS) mergers emit TeV radiation detectable with the CTAO. The current generation of GW detections is often affected by high uncertainty regarding the source position. CTAO is well-suited for the rapid coverage of large localization areas associated with GWs and possesses unparalleled sensitivity at very high energies (20 GeV - 300 TeV). We simulated CTAO's response on a set of phenomenological models describing the electromagnetic afterglow emission from short gamma-ray bursts (sGRBs) associated with GW events from BNS mergers. We optimized the follow-up strategies and estimated the number of joint sGRB-GW events stemming from BNS mergers detectable with CTAO in the future LIGO-Virgo-KAGRA (LVK) science run O5 (from 2027 onward).

Our study aims to maximize the physical interpretative value of CTAO observations by studying the connection to physical parameters driving simulated sGRBs, including the jet opening angle, luminosity, distance, and off-axis angle.

This work can be further extended to the next generation of GW detectors, like the Einstein Telescope and Cosmic Explorer.

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