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Accurate Gamma Ray Burst localization with LISA radiation monitors: another step towards multi-messenger astrophysics

The Laser Interferometer Space Antenna (LISA) is a forthcoming space-based gravitational wave (GW) observatory designed to detect low-frequency GWs (0.1 mHz - 1 Hz) using a triangular constellation of three spacecraft separated by ~2.5 million km. As the first space-based interferometer for GWs, LISA will provide groundbreaking observations of massive black hole mergers, extreme mass-ratio inspirals, and possibly new classes of astrophysical sources.

In addition to its primary mission, LISA mounts a set of radiation monitors, originally designed to measure cosmic rays and solar energetic particles. Since these monitors are sensitive to gamma photons and can easily achieve a time resolution of the order of 100 ms (used also in LISA Pathfinder), we show that by exploiting the photon arrival time delays between spacecraft, it is possible to reconstruct the direction of the incoming gamma-ray wavefront with excellent accuracy. Indeed, given the large separation between satellites and leveraging the GRB onset estimation obtained with the radiation monitor, we show that a LISA-like configuration can achieve sub-degree source pointing accuracy. This precision is competitive with most of the space-based GRB detectors and might be further refined by incorporating data from Earth-based gamma-ray observatories, using it as a fourth detection point. In this work, we also consider cases with improved time resolution down to 10 μs, achievable with nanosatellites (such as HERMES) onboard the LISA spacecrafts, demonstrating the potential that could be unlocked with dedicated onboard hardware.

These results highlight the potential of LISA to evolve into a true multimessenger observatory, bridging gravitational wave and high-energy astrophysics.

Collaboration(s)

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