

# Cosmology and Multi-Messenger Astrophysics with Gamma-Ray Bursts

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Gamma-Ray Bursts constitute one of the most fascinating and relevant phenomena in modern science, with strong implications for several fields of astrophysics, cosmology and fundamental physics.

In this review, I will focus on the perspective key-role of GRBs for cosmology and multi-messenger astrophysics. Indeed, the huge luminosity, the redshift distribution extending at least up to  $z \sim 10$  and the association with the explosive death of very massive stars make long GRBs (i.e., those lasting up to a few minutes) potentially extremely powerful probes for investigating the early Universe (pop-III stars, cosmic reionization, SFR and metallicity evolution up to the “cosmic dawn”) and cosmological parameters. At the same time, as demonstrated by the GW170817 event, short GRBs (lasting no more than a few s) are the most prominent electromagnetic counterpart of gravitational-wave sources like NS-NS and NS-BH merging events. Moreover, both long and short GRBs are expected to be associated with neutrino emission. I will also report on the status, concepts and expected performances of space mission projects (e.g. THESEUS, Gamow Explorer) aiming at fully exploiting these unique potentialities of the GRB phenomenon, thus providing an ideal synergy with the large e.m. facilities of the future like LSST, ELT, TMT, SKA, CTA, ATHENA in the e.m. domain, advanced second generation (2G++) and third generation (3G) GW detectors and future large neutrino detectors (e.g., Km3NET).

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