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Cosmology and Multi-Messenger Astrophysics with Gamma-Ray Bursts

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Since their discovery in the late '60s, Gamma-Ray Bursts constitute one of the most fascinating and mysterious phenomena for modern science, with strong implications for several fields of astrophysics 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 cosmological probes (early Universe, geometry and expansion rate of space-time, "dark energy" evolution). At the same time, short GRBs (lasting no more than $\sim 1-2$ s) are the most prominent electromagnetic signature of gravitational-wave sources like NS-NS and NS-BH merging events, and both long/short GRBs are expected to be associated with neutrino emission. I will also report on the status of the THESEUS space mission project, aiming at fully exploiting these unique potentialities of the GRB phenomenon.

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