



INSTITUTO DE FÍSICA
DE PARTÍCULAS Y DEL COSMOS

IPARCOS



Preprint Series in Particles and Cosmos Physics

n° IPARCOS-UCM-25-031

The Science of the Einstein Telescope

by A. Abac et al.
(including F.J. Llanes-Estrada, E. Lope Oter,
P. Navarro Moreno, J. Rubio, and D. Rubiera)

May 2025

Plaza de las Ciencias, 1 28040 Madrid, Spain

www.ucm.es/iparcos/



UNIVERSIDAD
COMPLUTENSE
MADRID



Abstract

Einstein Telescope (ET) is the European project for a gravitational-wave (GW) observatory of third-generation. In this paper we present a comprehensive discussion of its science objectives, providing state-of-the-art predictions for the capabilities of ET in both geometries currently under consideration, a single-site triangular configuration or two L-shaped detectors. We discuss the impact that ET will have on domains as broad and diverse as fundamental physics, cosmology, early Universe, astrophysics of compact objects, physics of matter in extreme conditions, and dynamics of stellar collapse. We discuss how the study of extreme astrophysical events will be enhanced by multi-messenger observations. We highlight the ET synergies with ground-based and space-borne GW observatories, including multi-band investigations of the same sources, improved parameter estimation, and complementary information on astrophysical or cosmological mechanisms obtained combining observations from different frequency bands. We present advancements in waveform modeling dedicated to third-generation observatories, along with open tools developed within the ET Collaboration for assessing the scientific potentials of different detector configurations. We finally discuss the data analysis challenges posed by third-generation observatories, which will enable access to large populations of sources and provide unprecedented precision.

