The ET science case

ET is planned as a broadband detector, with good sensitivity over the frequency range from 1 Hz to 10.000 Hz, which promises many interesting classes of sources. Binary neutron stars (NS) will sweep through the detector band from 1 Hz to 4 kHz, the signal lasting for several days as the system inspirals to a catastrophic merger event. The long observation time will allow to predict the location of the source and the precise merger time (to within milliseconds) when the system will coalesce, thereby facilitating simultaneous observation of the final merger of the two neutron stars using all windows of astronomical observation. Binary black hole (BH) mergers will also last for several hours, up to a day, in the detection band of ET again making it possible to observe such events using optical, radio and other telescopes.

ET will be able to observe binary inspirals with SNR's of 100's about once each year. Already a single such 'gold-plated' event will help explore the various nonlinearities of general relativity in ways that would never be possible with terrestrial or solar-system experiments or radio binary-pulsar observations. Moreover, the higher harmonics that are present in the waveform will reveal the nature of the space-time geometry in strong gravitational fields (as it results when compact stars merge) and will help us answer fundamental questions about the end-product of a gravitational collapse.

ET will observe a variety of different sources that will help resolve decades-old astronomy mysteries. One of the most important is the origin of gamma-ray bursts (GRB), which have remained an enigma for nearly four decades after their serendipitous discovery in the 60's and 70's. Because of ET's sensitivity to binary inspirals at high red-shifts, it should be possible to pin down the origin of gamma-ray bursts and to confirm or rule out the association of binaries of NS-NS/BH to GRBs and systematically study and understand different classes of gamma-ray burst sources.

ET design study participants:

Participant organization name	Country
European Gravitational Observatory	Italy-France
Istituto Nazionale di Fisica Nucleare	Italy
Max-Planck-Institut für Gravitationsphysik	Germany
Centre National de la Recherche Scientifique	France
University of Birmingham	United Kingdom
University of Glasgow	United Kingdom
NIKHEF	The Netherlands
Cardiff University	United Kingdom

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VIRGO

GEO 600

SEVENTH FRAMEWORK PROGRAMME

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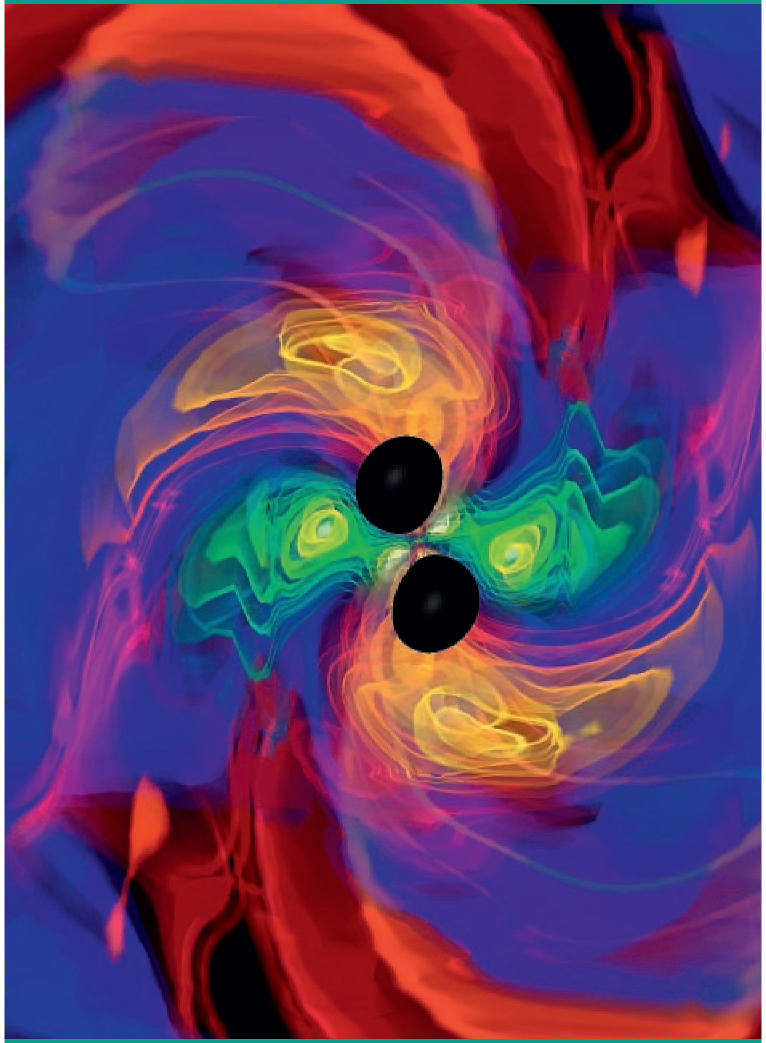
ET EINSTEIN TELESCOPE

The Einstein Telescope



GRAVITATIONAL WAVE ASTRONOMY

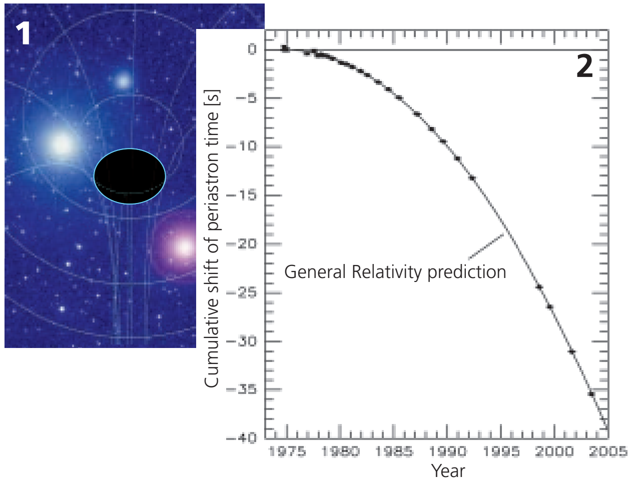
A NEW WINDOW TO THE UNIVERSE

The Einstein Telescope Design Study

Gravitational Waves

Gravitational waves are ripples in the fabric of space and time produced by violent events in the distant universe – for example, by the collision of two black holes or by the cores of superno-va explosions. Gravitational waves are emitted by accelerating masses much in the same way as radio waves are produced by accelerating charges – such as electrons in antennas.

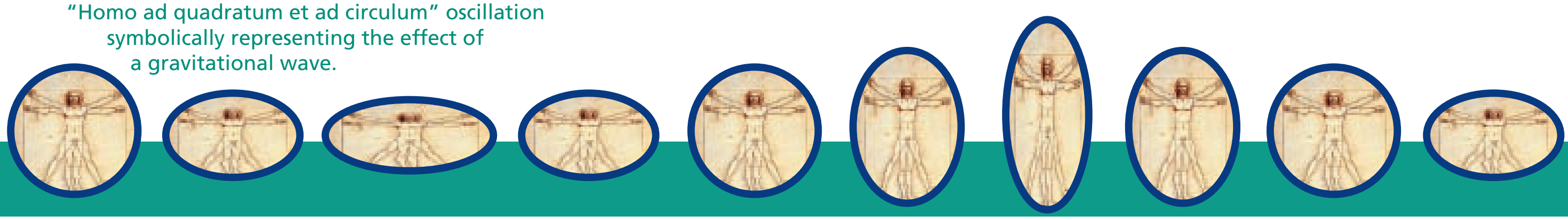
Predicted by Albert Einstein in 1916 as a consequence of his General Theory of Relativity the direct detection of gravitational waves is one of the most important and fundamental open questions of modern science. It will open the era of gravitational wave astronomy and will thus allow totally new insights into the universe. With gravitational waves, we can probe the parts of the universe that are hidden from view, and the 96 % of our universe that does not emit electromagnetic radiation at all.



1 Spacetime tells matter how to move and matter tells spacetime how to curve and twist.

2 Orbital decay of PSR B1913+16: The data points indicate the observed change in the epoch of periastron with date while the parabola illustrates the theoretically expected change in epoch.

"Homo ad quadratum et ad circulum" oscillation symbolically representing the effect of a gravitational wave.



The ET Design Study

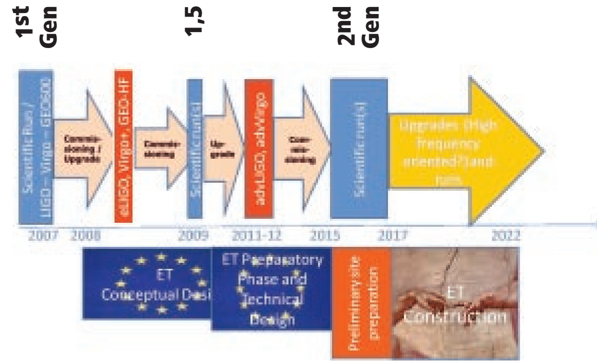
The Einstein Telescope (ET) project is a future 3rd generation gravitational wave observatory. The conceptual design for it is studied in a European-wide effort, which started in May 2008 and will be supported for about 3 years by the European Commission under the Seventh Framework Programme. This financial contribution of about 3M € will mainly be devoted to support young researchers.

The project addresses the main challenges of ET in five work packages:

- WP1 (Site identification):
  Definition of the site requirements and the proposition of possible sites in Europe.
- WP2 (Suspension requirements characteristics):
  Definition of the seismic, thermo-mechanical and control requirements of the suspension devices of the optics.
- WP3 (Topology identification):
  Find and define a conceptual design of the core interferometer with respect to geometry, topology and configuration that can significantly surpass the Standard Quantum Limit.
- WP4 (Astrophysics issues):
  Evaluate the science potential of ET for different geometrical and optical configurations, choice of materials and site, etc., each corresponding to a different sensitivity curve.
- WP5 (Management).

GW Detector Evolution

The future of the current gravitational wave detectors is well planned. Evolving from the initial machines to the second generation (the "advanced" detectors) the detectors will gain an order of magnitude in their sensitivity, increasing the detection rate by a factor of about 1000. The second generation of GW interferometers will make the detection of gravitational waves emitted by coalescing binary systems of neutron stars very likely within one year after operation, but the signal-to-noise level will not be sufficient for routine, precision GW astronomy and to verify Einstein's theory of general relativity in strong field conditions. The ET project is aiming exactly for this goal: to open a new era in astronomy. This third generation observatory will increase the observable volume of the universe by a factor of a million.



Evolution plan of the GW detectors in the world

The existing Virgo detector