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The Laser Interferometer Gravitational-Wave Observatory: Lasers at the Frontiers of Astrophysics

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The Laser Interferometric Gravitational-Wave Observatory (LIGO) is poised to open a new window on the universe - the detection of gravitational waves from distant large-scale astrophysical sources. Gravitational waves were predicted by Einstein almost 90 years ago but never been observed directly despite a number of experiments over the last 40 years. While there exists strong *indirect* evidence for gravitational waves, it is only with the construction of large-scale high precision interferometers that *direct* detection of gravitational waves is possible. Gravitational waves are miniscule dynamic strains applied to space-time by motion of massive astrophysical objects. A passing gravitational wave will expand and contract the distance between two mirrors ('test masses') in the arms of an interferometer. Direct observation of gravitational waves presents a formidable challenge, because the magnitude of the dynamic strain is expected to be infinitesimal, less than one part in 10^{-22}. The astrophysical motivation for detecting gravitational waves is compelling. Unlike the visible sky, the gravitational wave 'sky' is completely unexplored. The LIGO detectors and its partner GEO600 in Europe have the sensitivity to observe gravitational waves not only in our own galaxy, but in neighboring galaxies, thus opening an absolutely unique window into these phenomena. In the first part of the presentation, we will give an overview of gravitational waves - what they are and where they come from – and describe in general terms the techniques that gravitational wave astrophysicists use to hunt for them. In the second part of the presentation, we describe the LIGO interferometers emphasizing the critical role that lasers and optics play in its operation.