

Gravitational Waves and Binary Systems

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The recent discovery of several gravitational wave events by the two Laser Interferometer Gravitational-Wave Observatory (LIGO) interferometers, and by the Virgo interferometer, has provided the first observation of gravitational waves in the wave-zone, and has also brought the first direct evidence for the existence of black holes, and for a connection between coalescing binary neutron star systems and gamma ray bursts. These momentous observational events have been crucially helped by years of physico-mathematical developments on the motion and gravitational-wave emission of binary systems made of compact objects (black holes or neutron stars). The lectures will present: (i) the basic ideas and techniques of the general relativistic theory of the motion of compact objects; (ii) the analytical theory of the emission of gravitational waves by binary systems; and (iii) the theory of the back reaction of gravitational wave emission on the motion. Moreover, we shall present the analytical resummation technique (called the Effective One-Body, EOB, formalism) which led to the first prediction for the gravitational-wave signal emitted by coalescing black holes, and which has allowed one (after a suitable completion by some Numerical-Relativity data) to compute the bank of 200 000 accurate templates that has been used to search the first coalescence signals, and to measure the masses and spins of the coalescing black holes. The connection between EOB theory, self-force theory, classical scattering theory, and quantum scattering theory will also be discussed.