From the principle of relativity (special and general) to black holes and gravitational waves.

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Abstract

The principle of equivalence is an extremely powerful principle. Indeed, imposing that the laws of physics are the same in all (or a sub-class) of frames leads to a precise description of physical phenomena. These lectures are devoted to an introduction of Special and General Relativity with some applications to black holes and gravitational waves. No prerequisites are needed to attend to theses lectures since all notions will be introduced from the very beginning.

The first part of these lectures will be devoted to the principle of equivalence. It will be established that imposing that the laws of physics are the same in all inertial frames necessitates a reformulation of the structure of space. The four-dimensional Minkowski space-time with its associated Poincaré group will be introduced and the relation with non-relativistic physics identified. Extending the principle of equivalence to all frames gives rise to General Relativity which turns out to be a theory of gravitation. General Relativity modifies drastically the structure of space-time which becomes dynamical. In particular, the space-time is curved by matter. The Einstein equations describing gravitation will be given.

In the last part of these lectures two special solutions of the Einstein equations will be analysed. The Schwarzschild (and Kerr, time permitting) solution(s) describing black holes will be studied. Einstein equations are non-linear equations. In the the weak field approximation the equations become linear. It will be established that this approximation predicts gravitational waves. It will also be established that these equations describe a massless spin-two particle, the graviton. The graviton is the analogue of the photon for the Maxwell equations.

The lectures will take place at from 16:00 to 18:00 in

IPHC, Amphi Grunwald, Bât 25: 9, 14, 16, 21, 23, 28 March,

IPHC, second floor, salle pistache, Bât 27: 7, 30 March.

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