Foreword

The theory of special relativity holds a distinctive place within Physics. Rather than being a specific physical theory, it is (similarly to thermodynamics or analytical mechanics), a general *theoretical framework* within which various dynamical theories can be formulated. In this respect, a modern presentation of special relativity must put forward its essential structures, before illustrating them by concrete applications to specific dynamical problems. Such is the challenge (so successfully met!) of the beautiful book by Éric Gourgoulhon.

Contrary to most textbooks on special relativity, which mix the presentation of this theory with that of its historical development, and which sometimes write the specific form of "Lorentz transformations" before indicating that they leave invariant a certain quadratic form, the book by Éric Gourgoulhon is centred, from the very beginning, on the essential structure of the theory, i.e. the chrono-geometric structure of the four-dimensional Poincaré-Minkowski spacetime. The aim is to train the reader to formulate any relativity question in terms of four-dimensional geometry. The word *geometry* has here the meaning of "synthetic geometry" (à la Euclid), by contrast with "analytic geometry" (à la Descartes). Under the expert guidance of Éric Gourgoulhon, the reader will learn to set, and to solve, any problem of relativity by drawing spacetime diagrams, made of curves, straight lines, planes, hyperplanes, cones and vectors. He will get accustomed to visualizing the motion of a particle as a line in spacetime, to think about the twin paradox as an application of the "spacetime triangle inequality", to express the local frame of an observer as a four-dimensional generalization of the Serret-Frenet triad, to compute a spatial distance as a geometric mean of time intervals (via the hyperbolic generalization of the power of a point with respect to a circle), or to understand the Sagnac effect by considering two helices in spacetime wound in opposite directions.

Besides the pedagogical characteristic of being centred on a geometric formulation, the book by Éric Gourgoulhon is remarkable in many other ways. First of all, it is fully up to date, and very complete in its coverage of the notions and results where special relativity plays an important role: from Thomas precession to the foundations of general relativity, including tensor calculus, exterior differential calculus, classical electrodynamics, the general notion of energy-momentum ten-

sor and a noteworthy chapter on relativistic hydrodynamics. In addition, this book is sprinkled with enlightening historical notes, in which the author summarizes in a condensed, albeit very informative way the (sometimes very recent) results by historians of science. Finally, the book is richly laden with many examples of applications of special relativity to concrete physical problems. The reader will learn the role of special relativity in various domains of modern astrophysics (supernova nebulae, relativistic jets, micro-quasars), in the description of the quark-gluon plasma produced in heavy ion collisions, as well as in many high technology experiments: from laser gyrometers to the LHC, including modern replications of the Michelson-Morley experiment, matter wave interferometers, synchrotrons and their radiation, and the comparison of atomic clocks embarked on planes, satellites or the International Space Station.

I am sure that the remarkably rich book by Éric Gourgoulhon will attract the keen interest of many readers and will enable them to understand and master one of the fundamental pillars (with general relativity and quantum theory) of modern physics.

Thibault Damour
Professor at the Institut des Hautes Études Scientifiques
Member of the Académie des Sciences