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## Theory of Gravitation

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## 1. INTRODUCTION

The work on, and the understanding of, gravitation greatly influenced not only the physicist's conception of nature but also the development of all exact sciences. Newton invented the method of fluxions, and thereby laid down the foundations of calculus, in connection with his research on the motion of bodies and on the law of universal attraction.<sup>1</sup> The calculus of variations, the theory of differential equations and the perturbation methods of solving them arose directly from the needs of mechanics and astronomy. Through the work of Poincaré<sup>2</sup>, the consideration of global and stable properties of motions stimulated the birth of topology. The relativistic theory of gravitation of Einstein<sup>3</sup>, and his search for a unified theory<sup>4</sup>, enhanced the development of differential geometry. The notion of a superspace introduced recently by J. A. Wheeler<sup>5</sup> provides us with a concrete example of an infinite-dimensional manifold and leads to a number of difficult problems in the theory of Banach manifolds.

The theory of gravitation has had successes in all the fields where gravitational interactions are expected to play a dominant role. The laws of gravitation, very accurately checked within the solar system, seem to be applicable also on a much larger scale. It is amazing – and encouraging – that a simple theory of gravitation provides us with models of the entire Universe, some of which are at least in a qualitative agreement with the observations.

The achievements of the Newtonian theory of gravitation were later overshadowed by those of Maxwell's electromagnetic theory, by the discovery of the atomic nature of matter and by the development of quantum mechanics and relativity. The theory of general relativity although initially poor in experimentally verifiable predictions, greatly influenced our picture of the Universe and the understanding of space and time. It also gave rise to a hope – which is now believed to be false – of constructing a unified, geometric theory of electromagnetism and gravitation. In spite of its profound implications, for a long time Einstein's theory was being developed with little contact with the natural sciences. The situation has changed during the last years, thanks to the startling discoveries in astronomy, the progress in radio and radar measurements and the patient efforts to detect gravitational waves.<sup>6</sup> The theorists have followed suit and done relevant work on the process of collapse and formation of black holes, on new general relativistic effects, on the mechanisms of emission and absorption of

