Abstract

The work contained in the thesis is largely devoted to the study of geodesic evolution in exact radiative spacetimes of General Relativity (GR) and some modified theories of gravity, with emphasis on understanding gravitational wave memory effects. Although memory effects, which remain to be detected in observations, have been studied more in the realm of linearised gravity, our work here is restricted to the domain of exact radiative gravitational wave spacetimes which still remain primarily theoretical constructs. However, investigating such geometries are meaningful for understanding features of a theory of gravity as well as the basic physics related to memory.

Two types of radiative geometries are discussed in the thesis: (i) Exact plane waves, (ii) Generalised Kundt spacetimes. Unlike Kundt geometries, exact plane waves are vacuum solutions in GR. Two chapters deal with the study of memory effects in exact plane waves in GR using geodesic solutions, deviation and congruences. Obtained features include displacement memory, velocity memory and the focusing of geodesic trajectories induced by a gravitational wave pulse.

In the remaining chapters, different Kundt geometries (Kundt waves and Gyratons) are studied in GR, Brans-Dicke (BD) theory and Eddington-inspired Born-Infeld (EiBI) gravity. After finding out novel solutions of Kundt geometries in BD and EiBI theories, memory effects are analysed using geodesic and deviation equations. We find distinct memory features corresponding to different signatures of the scalar curvature. Particular attention is devoted to understanding the differences in the features of memory in each of these theories. Finally, a commentary explains why the deviation analysis may be more suited to the study of memory in such geometries.

In short, the work in this thesis tries to showcase some unique features of known and new exact radiative spacetimes in light of gravitational wave memory effects.

Keywords: General Relativity, modified gravity, exact radiative solutions, gravitational wave memory effects, geodesic equations, geodesic deviation, geodesic congruences.