In my thesis I present one particular example of formalism capable of describing the propagation of a family of light rays in a curved spacetime. It is based on the resolvent operator of the geodesic deviation equation for null geodesics which is known as the *bilocal geodesic operator* (BGO) formalism. The BGO formalism generalizes the standard treatment of light ray bundles by allowing observations extended in time or performed by a family of neighbouring observers. Furthermore, it provides a more unified picture of relativistic geometrical optics and imposes a number of consistency requirements between the optical observables.

The thesis begins with a brief introduction of the transfer matrix and its relativistic versions known as Jacobi propagators or bilocal geodesic operators. A brief literature review is given illustrating various interpretations of bilocal operators in contexts of extended objects, gravitational waves and seismology.

The second chapter is dedicated to the basics of differential geometry with the emphasis on the geometry of the tangent bundle, which will later provide a foundation for the BGO formalism. We start from the coordinate systems on the base manifold and its tangent bundle and then study coordinate-dependent and independent representations of induced higher-dimensional vectors. Next, we discuss the notion of the geodesic flow and define the BGOs in terms of this flow. Finally, we display how certain results obtained on the tangent bundle lead to the differential equations for BGOs.

In the third chapter I present my original work on a fully analytical derivation of the BGOs for static spherically-symmetric spacetimes. Firstly, I summarize two different techniques to obtain an exact solution, both resting upon symmetries of the spacetime and integrability of the geodesic and geodesic deviation equations. The methods are then applied to derive the solution both in coordinate and parallel-transported frames. Finally, the results are used to study optical distance measures in Schwarzschild spacetime.

In the fourth chapter I present several theorems about the inequality concerning optical distance measures. The result is valid irrespective of spacetime symmetries or lack thereof and depends on the validity of General Relativity together with rather standard assumptions about the matter content and the geometic optics approximation for the propagation of light. The chapter concludes with a short discussion about possibility of experimental verification or rejection of the mathematical result.

In the last chapter I summarize the content of the thesis and ponder about its possible extensions.