Preface

All the work presented here covers an analytic geometrical way to construct the shadow of black holes. The shape of the shadow varies in different space-times, i.e., it depends on specific properties of the black hole as, for example, the spin. My aim is to provide calculations as general as possible.

This short book summarizes the scientific results of my doctoral project where I generalized the existing calculations for the shadow of a Kerr black hole. I found analytical formulas for the boundary of the shadow for the general Plebański–Demiański class of stationary, axially symmetric type D solutions of the Einstein–Maxwell equations. As far as I know, such formulas did not exist before not even in the Kerr space-time. With my formulas, it is possible to calculate the shadow for observers at arbitrary positions. In addition, the shadow-plots can be compared with those of a moving observer. If the motion of the observer is in purely radial direction, then the aberration formula of Penrose is recovered from my formulas.

As pointed out in Chap. 1, the existence of the photon region is crucial for determining the shadow of a black hole. This results in the following natural structure of this thesis. In Chap. 2, I discuss in some detail the Plebański–Demiański class of space-times and review relevant properties of its metric. The geometrically important photon region and other interesting regions in the environment of a black hole are considered in Chap. 3. The last chapter, Chap. 4, is dedicated to deduce the formulas that describe the boundary curve of the black hole's shadow.

Large parts of the scientific results are already published in three papers. The corresponding paragraphs are marked in the following references which refer to my papers Grenzebach et al. (2014, 2015), Grenzebach (2015), respectively. Sentences marked with [*i*] can be found in total or only slightly modified in the *i*th paper.

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