

# Thesis Review

Faculty of Mathematics and Physics  
Charles University in Prague

- Supervisor's Review                       Referee's Review \*\*  
 BSc. Thesis                                       MSc. Thesis

Author:    Martin Krššák  
Thesis title:                                      On higher dimensional Kerr-Schild spacetimes  
Study program:                                      Physics / Theoretical Physics  
Submitted:    2009

Supervisor/Referee:                              Marcello Ortaggio, PhD.  
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## Thesis quality (technical field and expertise):

- excellent    very good    standard    substandard    nonconforming

## Objective accuracy (error appearance):

- nearly perfect    standard    frequent, but minor    serious errors

## Thesis results:

- original    both original and compiled    productive compilation    copied

## Thesis size:

- large    standard    just acceptable    insufficient

## Thesis quality (style and grammar, and graphic arrangement):

- excellent    very good    standard    substandard    nonconforming

## Misprints:

- negligible    acceptable number    very frequent

## Overall thesis quality:

- excellent    very good    standard    substandard    nonconforming

\*\* Copy and paste this check box, , if it is applicable.

**Supervisor's/Referee's Comments:**

Since the pioneering work of Kaluza and Klein in the 1920s, the idea of extra dimensions has reemerged over the years in modern unified theories and, in particular, supergravity and string theory are naturally expressed in more than four dimensions. Furthermore, the recently proposed brane world scenarios opened a possible, direct link to rich and qualitatively new observable phenomenology. Over the last few years, gravity in higher dimensions has thus developed rapidly into an active and interdisciplinary area of ongoing studies.

This motivated the submitted thesis, which studies classical aspects of gravity in more than four spacetime dimensions. More specifically, the present work analyzes an extension to any higher dimensions of the Kerr-Schild ansatz. In four dimensions, this is an important family of exact solutions which, most remarkably, contains the Kerr metric etc. In more than four dimensions it includes the generalization of the Kerr black hole found by Myers and Perry in the 1980s. However, after this early paper no systematic study of such geometries had been presented.

Mr. Krššák employed the recently developed generalization of the Newman-Penrose formalism, and this is thus one of the first works where this method has been employed in its full strength. The first part of the thesis is therefore a useful, self-contained review of such a technique in higher dimensions. In the second part, this is applied to obtain new general results about Kerr-Schild spacetimes.

Using an appropriate coordinate system, all connection and curvature components are computed, and employed to present the corresponding Einstein's equations in vacuum. The general solution seems very hard to find (even in four dimensions this is given only in implicit form, and thanks to the "miraculous" Kerr theorem). However, progress has been made with additional assumptions. In particular, using a suitable ansatz for the Kerr-Schild null congruence, Mr. Krššák rediscovered the metric for vacuum black strings. Although already known, this had not been systematically derived within the Newman-Penrose formalism before, and the details of the derivation are also useful as an illustrative example.

From a complementary viewpoint, the last section of the work analyzes asymptotic properties of Kerr-Schild spacetimes in full generality. The  $r$ -dependence of the curvature tensor is fully determined, which enables one, e.g., to discuss peeling behavior of the solutions. This is another new result of Mr. Krššák's work. We also believe that the general results of this thesis will provide a basis for further investigations, such as finding possible explicit new solutions and a discussion of the uniqueness properties of Myers-Perry black holes.

To summarize, the submitted thesis contains useful review parts as well as original new results, and it will also be helpful in future studies. Mr. Krššák diligently followed my recommendations in his research. He was able to quickly become acquainted with Relativity in higher dimensions, to learn the relevant new techniques, and to apply these in the specific context. However, he also already demonstrated independent thinking, for example in the derivation of the black string solutions. I am very happy with his work.

**Questions raised (and to be answered by the author during the Thesis Defence):****Supervisor's/Reviewer's recommendation on Thesis rating:**

excellent  very good  standard  reject

Done in Prague  
Date 15.9.2009

Name Marcello Ortaggio  
Signature 