Report on "Universal solutions in gravity, electrodynamics and nonabelian gauge theories"

by Mr. Martin Kuchynka

Hereby is a report on the thesis submitted for the degree of PhD by Mr. Martin Kuchynka entitled "*Universal solutions in gravity, electrodynamics and nonabelian gauge theories*".

The thesis consists of a short introduction and 4 chapters, each chapter being a research paper published or submitted for publication in international renowned journals. The first two papers are coauthored with other experienced researchers, while the two last papers are single authored.

The first chapter is based on the paper A*lmost universal spacetimes in higher-order gravity theories* coauthored with T. Malek, V. Pravda and A. Pravdova and published in Physical Review D. This paper contains new results when it comes to solutions which are "almost universal". Such solutions are interesting since they provide examples being solutions to a whole class of theories of gravity.

The second chapter is based on the paper *Einstein-Maxwell fields with vanishing higher-order corrections* coauthored by M. Ortaggio and also published in Physical Review D. In this paper they give a full characterisation of Einstein-Maxwell p-form solutions in arbitrary dimensions having vanishing higher-order corrections. In particular, their results are given in section III (p.26 in thesis). Here, several new results are given characterising such solutions.

Chapter 3 is based on the single-authored paper *Gauge fields with vanishing scalar invariants* published in Classical and Quantum Gravity. Here, the author extends established techniques to non-Abelian gauge fields. In particular, a full characterisation of gauge fields with vanishing scalar invariants (Theorem III.3, page 41 in thesis).

Lastly, chapter 4 is based on the paper *Einstein-Yang-Mills fields immune to quantum corrections*, submitted, single-authored. This paper is a continuation of chapter 3 and discussed the universal case in more detail. More new results are given, for example, Theorem 2 (page 53 in thesis). Explicit solutions are also given.

While the first to papers are multi-authored, the last two are single-authored. This implies that a significant part of the thesis is based on own work and thus shows an independence as a researcher. The new results given in this thesis give important new insights into the understanding og so-called "universal solutions" of theories of gravity with or without matter fields. In particular, the results point out the important class of spacetimes known as the Kundt spacetimes. Furthermore, the thesis contains techniques which have shown to be very fruitful in areas like relativity, the study of solutions to various theories of gravity, and to Lorentzian geometry. Thus, these results, as well as their techniques used, may prove to give useful applications to other areas like differential geometry and theoretical physics. Furthermore, these techniques are used with success within Yang-Mills theories and one might wonder if they can have some useful applications to modern particle physics and the interaction of fundamental particles. All in all, the author have shown that he masters previously developed techniques, as well as having knowledge of existing results and studies within the area. In addition, he has shown his ability to be creative and produce new and interesting results within the field.

If there was one weakness it would be that the introduction section is a bit short. It is difficult for somebody not in the field to be able to read and understand the work especially since some of the work is somewhat technical. This is, in part, remedied by some appendices in the actual papers, however, a somewhat extended introduction would perhaps increase the readability and presentations of the works. However, in all, this is not essential and the important results obtained clearly outweighs this weakness.

To conclude, I clearly think this thesis is well within what is required to obtain the degree of PhD.

Yours sincerely,

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