University at Buffalo
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Report on:

The habilitation thesis

Selected problems in theoretical gravitational physics

By David Kubiznak

It is my great honor and pleasure to write a report on Dr. Kubiznak's habilitation thesis. Dr. Kubiznak is a world class expert in gravitational physics. His work is very well known, highly cited and very influential. His publication record is impressive. The thesis is a commentary on a selected list of twenty papers published in peer reviewed international journals with very high impact factors.

Dr. Kubiznak work spans a large range of topics related to classical and quantum aspects of black hole physics, and also includes other topics like gravitational waves and modified gravity. In particular, Dr. Kubiznak started his stellar career with his seminal work on hidden symmetries of rotating black holes where he showed that equations of motion of fields propagating in the background of higher dimensional rotating black holes allow for separation of variables. With his co-authors, he then started a new field colloquially called "black hole chemistry" which involves studies of black hole thermodynamics and phase transitions. His initial paper has now been cited more than 800 times.

The thesis covers most of the relevant aspects of Dr. Kubiznak's work. For each sub-field of his study he provides a short but self-sufficient introduction. He then describes the most important details and importance of the work.

In the section 2.1, Dr. Kubiznak gives a nice overview of black hole thermodynamics for the most interesting case of a black hole placed in a space with a negative cosmological constant (AdS space). Promoting the cosmological constant into a dynamical variable provides the basis for introducing the pressure/volume term into black hole thermodynamics, which then leads to a radical new understanding of black holes in terms of chemical enthalpy, Van der Waals fluids, and heat engines. This led to a new subdiscipline of black hole thermodynamics known as the black hole chemistry, that Dr. Kubiznak pioneered.

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In section 2.2, Dr. Kubiznak describes his work on hidden symmetries of higher dimensional rotating black holes. Metric tensors describing such black holes do not possess enough manifest symmetries to allow for separation of variables for the fields propagating in their backgrounds. However, as Dr. Kubiznak demonstrated with his collaborators, these metrics possess the Killing–Yano tensor, which generates a tower of explicit and hidden symmetries that allow complete integrability of geodesic motion and separability of the scalar, spinor, and vector perturbations in these spacetimes.

In section 2.3, Dr. Kubiznak describes his work on modified gravity theories. While Einstein's general theory of relativity has been very successful, it still contains many open questions, in particular the question of quantization. Dr. Kubiznak made a solid effort to construct modifications to general relativity that include higher curvature corrections.

Finally, in section 2.4, Dr. Kubiznak describes his work on gravitational waves and experimental detection of the effect of the inertial frame dragging.

The thesis is well structured and very nicely written. It was a pleasure to read. I have no objections about the scientific content and writing style, which are both of very high quality. Since it is unlikely that I will be able to attend the presentation in person, if there is time during the defense, I would like to ask some questions:

1. Is it possible to generalize the results from the section 2.2 about separability and integrability to include black hole solutions in the massive gravity models (for example in the ghost-free de Rham–Gabadadze–Tolley (dRGT) model)?

2. In the context of modified gravity models, Dr. Kubiznak obtained a well-defined $d \to 4$ limit of the Gauss–Bonnet Gravity by generalizing a method of Mann and Ross used earlier to obtain a limit of the Einstein's gravity in $d = 2$ dimensions. Will this this effective dimensional reduction suffer from the so-called dimensional reduction anomaly discovered by Frolov and Zelnikov in Phys.Rev. D61 (2000) 024021?

I noticed the report on the originality check of this thesis performed by Turnitin system. At a closer inspection of the data, it is obvious that a relatively high percentage of coincidence (49%) in this check is due to the fact that Dr. Kubiznak included twenty of his own papers accompanied by his commentary.

My impression is that the habilitation thesis titled " Selected problems in theoretical gravitational physics" by Dr. Kubiznak meets and exceeds the requirements expected of a habilitation thesis in Mathematical Physics. Dr. Kubiznak is a well established and respected researcher in the field of

Mathematical Physics and I enthusiastically support his application without any reservations for the position of an Associate Professor.

Sincerely,

[redacted]

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