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This is a report on the PhD thesis submitted by Marek Liška to the Charles University in Prague.

Jacob Bekenstein suggested back in the 70's that there was a deep connection between black holes and thermodynamics. This connection became clairer after the famous result by Stephen Hawking that one can see black holes as black bodies with a non-zero temperature. This connection has been one of the central topics of research in gravitational physics for the last 50 years. For example, this connection led Ted Jacobson in the 90's to suggest that the relation between gravity and thermodynamics goes way beyond black holes: the very Einstein equations can be deduced following a thermodynamic argument, or using a slogan, gravity reduces to thermodynamics.

Mr. Liška PhD thesis takes Jacobson's idea as starting point and develop a large quantity of new material around it. As an early stage, he clearly identifies that the gravity that can be deduced directly from thermodynamics arguments is not Einstein gravity but instead a gravitational theory closely related to it: the so-called Weyl Transverse gravity. A large part of the thesis is devoted to understand better the structure of this theory of gravity. In particular, he starts developing the covariant phase space formalism for WT gravity and other more general Weyl and transverse diffeomorphisms invariant theories. Within this formalism he then obtains the first law of thermodynamics and an identification of Wald's entropy using WT gravity. These are interesting additions to the literature on the subject.

A second part of the thesis is devoted to present a complete argument showing how WT gravity would emerge in a system if only the systems behaves thermodynamically and strong equivalence principle applies. This chapter serves to revise and clean up the different arguments put together in the literature.

After the main ideas and formalism have been presented, the thesis turns to which in my opinion is its most interesting and novel aspect. The test acknowledge that in several fundamental derivations of the entropy law for black holes, different approaches found that apart from the straight area law there exist a subdominant logarithmic contribution. Mr Liška takes this modified entropy law and investigate which modified gravitational equations could lead to it. For instance, he identifies the necessity of adding a higher-derivative term in the modified WT gravity (or Einstein) equations, the square of the traceless Ricci tensor. They show that this term is not obtainable from any local WTdiff invariant action, nor even from any purely metric action. The final nature of this term remains unknown.

To end up the thesis, he presents some physical implications that the modified Einstein equations might have in a simple cosmological setting. He argues that this term might led to some quantum bounce but I think it is fair to say that this result is still inconclusive.

Mr. Liška has been able to publish 12 articles in high-quality journals during his predoctoral period (most of this material is included in his PhD thesis). Some of these articles have already accumulated a significant number of citations. Thus, the thesis has obtained already significant international recognition. On the other hand, all the

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works and results presented in the thesis revolve around a specific topic of gravitational physics: the connection gravity/thermodynamics. This makes the thesis a very self-consistent document.

It is clear to me that Mr. Liška has already acquired the required level of expertise on gravitational physics to obtain a PhD degree. I hereby congratulate Marek Liška and his thesis adviser Ana Alonso-Serrano for a very professional work.

Sincerely yours,

Carlos Barceló, Senior Researcher at the Institute of Astrophysics of Andalusia, CSIC, Spain.

PS: In a separate file you can find some comments and questions regarding Mr. Liška's thesis.

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