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To Whom it may concern

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Report on the thesis

"Beyond the standard model of particle physics, beyond the cosmological standard model: a quantum gravity perspective"

by Jan Henryk KWAPISZ

This thesis deals with various different aspects of the question of what could come after the well established standard models of particle physics and cosmology, or, in more technical terms, what could be the UV completion of these models. In it the author, Jan H. Kwapisz, discusses several current ideas and ansätze towards this goal, with special emphasis on the asymptotic safety approach, but also covering other approaches such as string theory and Horava-Lifshitz gravity. Amongst others these topics include:

[1] An application of Wilsonian renormalization techniques to the $1/r^{\wedge 2}$ potential, producing exact solutions of the RG equation. Although this is more of a "warm-up" example the author nevertheless is able to exhibit some interesting and exemplary properties of such systems.

[2] An application of asymptotic safety ideas to string theory by studying certain string amplitudes (in work with K.A. Meissner), exploiting the fact that higher order curvature corrections are calculable, at least in principle, unlike for the common asymptotic safety scenarios. In my opinion this is one of the most interesting results of this thesis, as it

combines string theory and the idea of asymptotic safety in a way I have not seen before, and also provides some entirely different insights for the asymptotic safety scenario different from those found in the standard literature.

[3] A study of radiative symmetry breaking in Grand Unified Theories (GUTs), with a systematic investigation of the minima of the associated Coleman-Weinberg type potentials, which leads to restrictions on viable effective low energy theories. In particular the author succeeds in excluding specific symmetry breaking chains from SO(10), in particular one involving the Pati-Salam model.

[4] A further chapter deals with domain walls and their evolution, as they arise in symmetry breaking of GUT models. This in particular includes a study of their formation and subsequent evolution.

[5] A discussion of various GUT models from the perspective of the asymptotic safety program, linking up to earlier work on the determination of the Higgs mass. In particular it is shown that with appropriately chosen extensions (new scalars and gauge bosons) the Higgs mass can be tuned to the observed value, thus providing very relevant constraints on BSM model building.

[6] A study of the conditions enabling eternal inflations. This is one of the `hot topics' of current research in quantum cosmology, especially in view of the tension between the existence of deSitter vacua and string theory (which for all we know, does not seem to admit stable deSitter-type solutions). The author argues that asymptotic safety is in a somewhat better position as it has no problem with deSitter type vacua, hence there is no such tension here. This part of the thesis confirms and complements previous work on asymptotically safe cosmology.

The work of Jan Kwapisz has resulted in 11 publications most of which have appeared in refereed journals (Phys. Rev., Phys. Lett. B, JCAP, ...). Altogether it is an impressive and comprehensive piece of work. With it the author has demonstrated an astonishing versality and breadth of knowledge, as well as his ability to apply modern concepts of quantum field theory and cosmology in innovative ways. My only (very mild) criticism would be that the choice of different topics is so varied that at times one loses the central thread, which makes the thesis somewhat difficult to follow through.

In view of these comments I am therefore happy to recommend the thesis for acceptance with the grade MAGNA CUM LAUDE.

Sincerely,

H. Nicolai

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