Five recent publications (C. Wetterich)

(1) **The great emptiness at the beginning of the Universe**
arXiv: 1912.00792

It is shown that our Universe did not start with a physical singularity. The beginning epoch was an empty Universe with a very slow increase of the mass of particles. This beginning epoch can have lasted since eternity. A field transformation or change of coordinates in field space maps the beginning epoch to standard models of inflationary cosmology. The big bang singularity is an artefact of a singular choice of coordinates in field space, similar to the South pole appearing as a singularity for certain maps of the earth.

(2) **Quantum scale symmetry**
arXiv: 1901.04741

Quantum scale symmetry is a fundamental symmetry of Nature. It is realized if no intrinsic parameter with dimension length or mass is present. All observed scales arise from a spontaneous breaking of this symmetry. Quantum scale symmetry is necessarily induced by any fixed point in the flow of couplings, as characteristic for quantum gravity defined as a renormalizable quantum field theory. This report reviews the important predictions of scale symmetry (partly by the author) for cosmology and particle physics as, for example, the prediction of the mass of the Higgs boson in the range where it later was discovered, or the prediction of the presence of dynamical dark energy.

(3) **Quantum gravity predictions for the fine-structure constant**
with A. Eichhorn and A. Held.
Phys. Lett. B782 (2018), arXiv: 1711.02949

The formulation of quantum gravity as a consistent quantum field theory is based on a fixed point in the flow of couplings. The values of so called ``irrelevant couplings''at a fixed point can be predicted. One such coupling is the self-interaction of the Higgs boson which has led to the successful prediction of its mass by M. Shaposhnikov and C. Wetterich. This letter argues that for grand unified theories coupled to quantum gravity also the values of the gauge couplings become predictable. A given grand unified model can predict the fine structure constant. Quantitative predictions still require an improvement in the reliability of functional renormalization group equations for quantum gravity.

(4) **Emergent scale symmetry – Connecting inflation and dark energy**
with J. Rubio
Phy. Rev. D96 (2017) 063509, arXiv: 1705.00552

Quantum scale symmetry plays an important role for cosmology. It emerges both in the infinite past and infinite future as the value of a scalar field goes to zero or infinity. The corresponding cosmology describes a crossover between two fixed points. The vicinity of the ``past fixed point'' accounts for models of inflationary cosmology, and the vicinity of the „future fixed point" is characterized by dynamical dark energy or quintessence. This paper describes in detail resulting models which unify inflation and quintessence, both being attributed to the same scalar field.

(5) **Gauge hierarchy problem in asymptotically safe gravity – the resurgence mechanism**
with M. Yamada
Phys. Lett. B770 (2017) 268, arXiv: 1612.03069

The gauge hierarchy problem concerns the understanding of a very small parameter in particle physics, namely the ratio 10^{-16} of the scale of weak interactions (Fermi scale) as compared to the scale of gravity (Planck mass). Attempts for its explanation are at the origin of many models in particle physics, as supersymmetry or technicolor. If the mass term for the Higgs scalar is an irrelevant coupling at the fixed point of quantum gravity, one indeed predicts a very small gauge hierarchy. This could be a road towards a solution of one of the central problems in particle physics