Neunhof, 25 February 2016

Dear Han,

when we say that a finite vacuum energy of elementary fields "does exist" or "does not exist", then we mean that the zero-point energy, predicted by quantum field theory[1], does or does not have consequences, which can be made visible by appropriate experiments.

Exactly two types of experimental checks are known, which could prove the existence of a zero-point-energy of elementary fields: The gravitational effect should be observable, and the Casimir effect should be measurable.

* The observed gravitational effect is by more than a factor of $10^{58} \ldots 10^{121}$ smaller than predicted by general relativity theory [1, eq. (19)]. But this does not stringently disprove zero-point-oscillations of elementary fields, because the extremely small gravitational effect could be explained by an appropriately fine-tuned cosmological constant.
* The Casimir-force has been confirmed beyond doubt. But this force does not stringently prove zero-point-oscillations of the electromagnetic field, because it could be explained (minimum) as well as a van der Waals force, which is transmitted by virtual photons, and not at all related to zero-point-oscillations of the electromagnetic field.

Hence there is no compelling experimental proof for the existence or not-existence of the zero-point-energy of elementary fields.

Casimir indeed gave only marginal informations in [2] on the derivation of the Casimir force. Some years ago I compiled a very detailed step-by-step account of his calculation [3, pages 16–22], taking many useful hints from Greiner, cited there.

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[1] more specifically: predicted by that type of QFT, which is based on canonical quantization

In the same article [3] there are many considerations on the zero-point energy of quantum fields. You may want to have a look at that article.

Most theoretical physicists, who are working on the Casimir effect, are using the notions Casimir force and van der Waals force almost synonymously, even though the Casimir force rests on the assumption of zero-point-oscillations of the electromagnetic field, while van der Waals forces can be explained by exchange of virtual photons, without the assumption of zero-point-oscillations. For example: Julian Schwinger insisted until his death, that his particular method of quantum electrodynamics was superior to canonical quantum electrodynamics, because it goes without zero-point-oscillations of the electromagnetic field. In 1978 he published an article (cited as [35] in [3]) together with de Raad and Milton, in which these authors demonstrated that Schwingers method of QED does exactly reproduce Casimirs formula (last equation in [2]) for the Casimir force, even though their method does not assume zero-point-oscillations. Twenty years later, the selfsame Milton published his monograph "The Casimir Effect. Physical Manifestations of Zero-Point Energy" (cited as [10] in [4]), from which I took the (slightly polemic) title of [4].

By today, there is — to my best knowledge — no clear-cut experimental evidence for the existence or non-existence of zero-point-oscillations of elementary fields. Both general relativity theory and quantum field theory seem to be flexible enough, to accommodate for both alternatives. But there are two considerations within QFT, indicating that actually there exist no zero-point-oscillations of elementary fields:

- The first argument is the basic conceptual difference between metals and boundaries, outlined in [4].
- Only by last year I became aware of a second argument: Upon dimensional regularization, the zero-point-energies of elementary

fields change signs. The zero-point-energies of elementary boson fields become negative, the zero-point-energies of elementary fermion fields become positive. This is extremely strange, to say the least. Obviously the strange change of signs would disappear, if the zero-point-energies of all elementary fields would be simply zero.

This second argument is outlined in [1]. There I suggest to modify the rule of canonical quantization, such that the zero-point-oscillations of all elementary fields are removed. As I think that these findings are very important, I tried to get the article published in a serious, peer-reviewed journal. Of course I removed the quite hand-waving sections 6 and 7, which certainly would impede acceptance. Still the article was rejected by one american and one european journal, mainly because it seemed "too speculative" to the referees, i. e. it is too far off the mainstream. I was not really surprised: Renowned scientists may sometimes be entitled to suggest a change of a law of nature, but certainly not an unknown outsider like me.[2]

You may like to have a look at the "hand-waving" section 7 of [1], which displays some considerations on the Casimir effect.

Best regards

Gerold

mailto: gerold.gruendler@astrophys-neunhof.de

[2] I am a retired physicist, spent my professional life in the electronics industry.

[1] G. Gründler : *Canonical quantization of substrate-less fields* , arXiv: 1506.08647 (2015), http://arxiv.org/abs/1506.08647

[2] H. B. G. Casimir : *On the attraction between two perfectly conducting plates* , Proc. Kon. Nederl. Akad. Wetensch. **51**, 793 – 796 (1948) http://www.dwc.knaw.nl/DL/publications/PU00018547.pdf

[3] G. Gründler : *Zero-Point Energy and Casimir-Effect*, APIN Circular se08011 (2013) http://www.astrophys-neunhof.de/mtlg/se08011.pdf

[4] G. Gründler : *The Casimir-Effect: No Manifestation of Zero-Point Energy* , arXiv: 1303.3790 (2013) http://arxiv.org/abs/1303.3790