Lightcone Normality of Infravacuum States

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Imagine an electron moving in empty space. According to the laws of Classical Electrodynamics it is always encircled by a distant halo of electromagnetic waves moving with velocity of light. Whenever the electron changes velocity, new waves are emitted - so far there is nothing mysterious about it, this is how every radio transmitter works. However, low frequency part of this radiation 'remembers' the slow, quadratic decay of the Coulomb force and this becomes a problem when Quantum Mechanics enters the game. Here the electromagnetic wave is understood as a flux of photons - massless quantum particles - and the laws of Quantum Mechanics tell us how to compute probabilities of physical processes they are involved in. Unfortunately, such computations often give meaningless, divergent results which can be traced back to the classical Coulomb Law mentioned above. Many sophisticated computational methods have been developed to tame the infrared problem. A conceptually attractive, though radical approach has been proposed in 2014 by D. Buchholz and J. Roberts. These authors suggest to replace the usual Minkowski spacetime $\mathbb{R}^4$ by its subset - namely the future lightcone. By the laws of Special Relativity, each of us only has access to its future lightcone anyway!

This project belongs to a line of developments which test the Buchholz-Roberts proposal. We want to find out, if infrared problems really disappear inside the future lightcone. As a step in this direction, we have a look at so called infravacuum states, which are among the computational tools for taming the infrared problems, mentioned above. They can be seen as a complicated change of variables in the equations of motion of the physical system, which is designed to shift infrared problems under the rag. As such, the infravacuum states have a complicated infrared singularity on Minkowski spacetime and it is a good test of the Buchholz-Roberts approach to find out if this singularity disappears after restriction to the future lightcone. This is, in general terms, the goal of our project. To reach it, we will use and further develop methods ranging from abstract theory of C^*-algebras to very concrete computations of traces of certain matrices.