A self-confined high-power Cherenkov oscillator operating at high frequency

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We present initial predictions for the performance of a novel microwave source, in form of a high-power Cherenkov oscillator, that operates with no externally applied magnetic insulation of the propagating electron beam; i.e. the source relies solely on the self-fields of the electron beam for propagation. The result being that the conversion efficiency - that is, the energy extracted from the electron beam to the growing electromagnetic wave - is closely linked to the overall energy efficiency of the source.

Appearing similar in construction to the conventional, magnetically insulated, relativistic Backward-Wave Oscillator (BWO), the source has been termed a Self-Insulating BWO (SIBWO). Conversion efficiencies in excess of 30% have been predicted in simulation, using CST Studio Suite, corresponding to output powers in excess of 300MW from a 500keV, 2kA electron beam, operating in the expected TM01 mode at ~9.4GHz.

As the operation of the source is intrinsically tied to the quality of the propagated electron beam, a tolerance study has been performed, varying the critical beam parameters over the range expected in experiments. The results show the efficiency remains better than ~20%, even when operating with a relatively poor-quality beam (for e.g. showing large angular spread). Examination of the effect of variation in the mean beam energy, over an extended range of 400 - 600keV, showed the efficiency of the source remaining above 20%, across this range.

Pair production rate in a thermal bath by thermal quantum field theory

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The linear Breit-Wheeler pair production is likely to be observed from the recent experiment. However, it requires high energy photons, and it has a predictable low reaction rate. On the other hand, the Schwinger pair production only by a constant electric field is also hard to be observed under the current experiment condition. The multiple photons involved process, a thermal bath, is a possible way to make the production rate significant enough to be observed any time soon.

Thomas Weaver's has done the relevant research in the 1970s, where he calculated the production rate semi-classically. The semi-classical calculation is extremely complex and ineffective. Regarding the weak interaction between photon and electron, in a nearly thermal equilibrium state, we can ignore the recombination of the process and then easily redefine propagators in a thermal bath. Therefore, we investigate the electron-positron pair production rate in a thermal photon background using finite-temperature Schwinger-Keldysh Formalism from thermal quantum field theory. And we compare our calculation result with Weaver's semi-classical calculation result in tree level and one thermal loop level. We find the calculation results of the production rate are the same at the tree-level. However, with the one-loop correlation, the thermal effect becomes dominant at some temperature region. Therefore, the three input photons process is also investigated to understand the turning temperature in the thermal bath. We can argue that thermal QFT is an effective method to do temperature involved quantum process calculation, especially in the low-temperature region. Furthermore, it is the solid step for further pair production studies like the dynamically assisted Schwinger pair production and a thermal bath or the non-thermal pair production in extremely cosmology condition.