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Physical phenomena in strong background fields differ from those in weak ones. The production of charged particle pairs in a strong electric field, known as the Schwinger effect, is one of the most prominent aspects of nonperturbative quantum electrodynamics (QED), and Hawking radiation from black holes is another phenomenon; both of which cannot be found by the weak field method.

Heisenberg-Euler and Schwinger [1] found the one-loop effective action in a strong constant electromagnetic field by computing the interactions of the negative-energy electrons in the Dirac sea with all even numbers of photons from the background electromagnetic field (see Fig. 1), and showed that the Dirac vacuum under such a field becomes a polarized medium [2].

When the electric field is comparable to the critical field $E_c = m^2 c^3 / e\hbar = 1.3 \times 10^{16}$ V/cm, electron-positron pairs are significantly produced to have the mean number of pairs as

$$\mathcal{N}(E) = e^{-\frac{\pi m^2}{eE}},$$

where we use the cgs Gaussian units with $c = \hbar = 1$.

Figure 1: Conference venue.

[1] J. Schwinger, *Phys. Rev.* **82**, 664 (1951).
[2] R. Ruffini, G. Vereshchagin, S.-S. Xue, *Phys. Rep.* **487**, 1 (2010).