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In-out formalism for one-loop effective actions in QED and gravity

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The in-out formalism is a systematic and powerful method for finding the effective actions in an electromagnetic field and a curved spacetime provided that the field equation has explicitly known solutions. The effective action becomes complex when pairs of charged particles are produced due to an electric field and curved spacetime. This may lead to a conjecture of one-to-one correspondence between the vacuum polarization (real part) and the vacuum persistence (imaginary part). We illustrate the one-loop effective action in a constant electric field in a Minkowski spacetime and in a uniform electric field in a two-dimensional (anti-) de Sitter space.

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