Fermionic Preheating: Renormalization, backreaction and initial conditions

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(Dated: March 11, 2019)

In this work we explain how to deal with the semiclassical equations of motion of a quantized fermion interacting with an oscillating homogeneous classical scalar field. This kind of equations appears in fermionic preheating, where the inflaton acts as a background scalar field oscillating around the minimum of its potential, and decays nonperturbatively into fermions due to its Yukawa interactions.

In this scenario, the most relevant physical observables are the stress-energy tensor $\langle T_{\mu\nu} \rangle$ and the bilinear $\langle \bar{\psi}\psi \rangle$. It is well-known that their formal expressions are divergent and one needs a renormalization prescription to obtain a finite an well-defined result to be plugged into the semiclassical equations.

In a gravitational context, and for homogeneous and time-dependent spacetimes, a generic expression for $\langle T_{\mu\nu} \rangle$ was obtained for scalar fields by means of the so-called adiabatic regularizacion/renormalization scheme[1, 2]. The method is widely used in cosmology and it turns out to be very efficient to implement numerical computations. More recently, it has been extended to spin-1/2 fields [3, 4]. The adiabatic regularization method has also been extended for non-gravitational backgrounds, like electric [5, 6] or scalar fields [7]. We will use a modified version of this adiabatic subtraction scheme with scalar backgrounds in order to regularize our physical observables.

In order to solve the semiclassical (backreaction) equations in a consistent way it is also very important to fix the initial conditions in a proper way, otherwise, unphysical ultraviolet divergences will appear in the temporal evolution. We will discuss how to fix those initial conditions and if they are always well defined.

[1] L. Parker and D. J. Toms, *Quantum Field Theory in Curved Spacetime: Quantized Fields and Gravity*, Cambridge University Press, Cambridge, England (2009).
[2] N. D. Birrell and P. C. W. Davies, *Quantum Fields in Curved Space*, Cambridge University Press, Cambridge, England (1982).
[3] A. Landete, J. Navarro-Salas and F. Torrenti, *Phys. Rev. D* **88**, 061501 (2013); *Phys. Rev. D* **89** 044030 (2014). A. del Rio, J. Navarro-Salas and F. Torrenti, *Phys. Rev. D* **90**, 084017 (2014).
[4] A. del Rio, A. Ferreiro, J. Navarro-Salas and F. Torrenti, *Phys. Rev. D* **95**, 105003 (2017).
[5] A. Ferreiro and J. Navarro-Salas, *Phys. Rev. D* **97**, 125012 (2018).
[6] A. Ferreiro, J. Navarro-Salas and S. Pla, *Phys. Rev. D* **98**, 045015 (2018).
[7] A. del Rio, A. Ferreiro, J. Navarro-Salas, and F. Torrenti *Phys. Rev. D* **95**, 105003 (2017).

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