Particle Production from Geometric Transition in Expanding Universe

Sang Pyo Kim

Department of Physics, Kunsan National University, Gunsan 573-701, Korea

e-mail address: sangkim@kunsan.ac.kr

It has been known for long that an expanding universe produces cosmic particles [1]. In the in-out formalism, particle production in time-dependent backgrounds is a consequence of the difference between the in-vacuum and out-vacuum, which results in a complex $S$-matrix whose magnitude is less than one. Kim and Page showed that the instanton action in the complex time determines the magnitude of the $S$-matrix for a charged particle in time-dependent electric fields [2] and in dS$_2$ or AdS$_2$ with a uniform electric field [3] and in global coordinates of dS spaces [4].

In this presentation, we further argue that the geometric transition in the complex time [5] of the Hamilton evolution operator for time-dependent backgrounds such as expanding universes and/or electric fields is the origin of particle production [6].

[1] L. Parker, Physical Review Letters 21, 562 (1968); Physical Review 183, 1057 (1969)
[2] S. P. Kim and D. N. Page, Physical Review D 75, 045013 (2007).
[3] S. P. Kim and D. N. Page, Physical Review D 78, 103517 (2008).
[4] S. P. Kim, Journal of High Energy Physics 09 (2010) 054.
[5] S. P. Kim, J. Kim and K-S. Soh, “Matrix Operator Approach to Quantum Evolution and Geometric Phase,” [arXiv:1212.2680].
[6] S. P. Kim, “Geometric Transition as Origin of Particle Production in Time-Dependent Backgrounds,” in preparation (2013).