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Mathematical Physics

Huygens' Principle for the Klein-Gordon equation in the de Sitter spacetime

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In this article we prove that the Klein-Gordon equation in the de Sitter spacetime obeys the Huygens' principle only if the physical mass m of the scalar field and the dimension $n\geq 2$ of the spatial variable are tied by the equation $m^2=(n^2-1)/4 $. Moreover, we define the incomplete Huygens' principle, which is the Huygens' principle restricted to the vanishing second initial datum, and then reveal that the massless scalar field in the de Sitter spacetime obeys the incomplete Huygens' principle and does not obey the Huygens' principle, for the dimensions $n=1,3$, only. Thus, in the de Sitter spacetime the existence of two different scalar fields (in fact, with m=0 and $m^2=(n^2-1)/4 $), which obey incomplete Huygens' principle, is equivalent to the condition $n=3$ (in fact, the spatial dimension of the physical world). For $n=3$ these two values of the mass are the endpoints of the so-called in quantum field theory the Higuchi bound. The value $m^2=(n^2-1)/4 $ of the physical mass allows us also to obtain complete asymptotic expansion of the solution for the large time.
Keywords: Huygens' Principle; Klein-Gordon Equation; de Sitter spacetime; Higuchi Bound

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