Locality and Evolution of Cosmological Fluctuation

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We study the evolution of density fluctuation throughout possible phase transitions considered in stringy motivated cosmological scenarios. We study the problem from the viewpoint of locality. As the result, we give the most general matching condition allowed under the requirement of locality, i.e., a local effect not to propagate to infinite distance during the phase transition. It turns out the class of matching condition is unaltered from that allowed in the framework of general relativity. We see the matching condition to give the scale invariant spectrum requires non-local effects around the bounce. Possibilities of having non-local effects such as the noncommutativity of the space time around the bounce are also studied.

In stringy motivated cosmologies with bouncing of the universe around the big-bang, the most important question is whether the scale invariant spectrum observed in cosmological microwave background can be obtained after the bouncing of the universe. In some scenarios, the mechanism to obtain scale invariant spectrum without having the inflation was proposed. Before the bounce the universe is assumed to be Minkowskian. The time evolution of the metric fluctuation has been studied in literatures. Before the bounce, there are growing mode and constant mode in the metric fluctuation. The emergence of the scale invariant spectrum depends on how these two modes evolve through the bounce. It was argued stringy effect can provide non-trivial mixing of these two modes which is necessary to obtain the scale invariant spectrum. We study the problem of matching condition without assuming general relativity and found the most general form of the matching condition under the requirement of locality. In models such as the ekpyrotic scenario, the bounce can be interpreted as collision of two branes in extra-dimensions. In such a situation locality condition seems to be satisfied. We derived the most general matching condition and see non-local effects are necessary to obtain the proposed mixing of the growing and constant modes.

In string theory, noncommutativity of the space time is known as the possible modification of the space-time structure. Hinted by the low-energy effective action of the noncommutative field theory, we studied the possible modification of the evolution equation for the metric fluctuation with non-local effects. As the result we found the resulting spectrum typically show rapid oscillation with respect to the wave number which contradicts with the data. On the other hand, scale invariant spectrum can be obtained if the time interval for the bounce is short enough and the non-locality is rather mild. In this case, there also appears a slight deviation to a red spectrum from the scale invariant behavior.