Noncommutativity and Tachyon Condensation

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Noncommutative generalization of the geometry is an interesting subject partly because it is expected to be related to a quantization of the general relativity which is based on Riemannian geometry. It has been shown that some noncommutative geometry, for examples, noncommutative torus, noncommutative plane and fuzzy sphere play important roles in D-brane physics in string theory. It should be emphasized that in these examples the noncommutative Dp-brane can be equivalently described as BPS D0-branes with matrix valued coordinate Φ^μ which do not commute each other and this may be the origin of the noncommutativity.

On the other hand, a noncommutative generalization of the Riemann geometry was given by Connes where the spectral triples which include a Dirac operator play a central role. In string theory, remarkably, the spectral triples of the noncommutative geometry á la Connes can be identified as configurations of the unstable D0-branes branes. Actually, we can construct any D-branes from infinitely many unstable D0-branes. Therefore this unstable D0-brane picture gives unified view for the all D-branes, including pure D-branes, the D-branes on the fuzzy sphere and the flat noncommutative D-branes and could be a starting point to consider a nonperturbative definition of a string theory. Then, it is natural to ask how this unstable D0-brane picture incorporates the noncommutativity of the fuzzy D-branes, etc, which are represented as the mutually noncommutative matrix coordinates in the BPS D0-brane picture. This question is very interesting since the matrix coordinates of the unstable D0-branes corresponding to the Dp-brane with the flux are mutually commutative and there does not seem noncommutativity.

In the paper, we show that the tachyon condensation of the unstable D0-branes induces the noncommutativity. We see that in the infinite tachyon condensation limit, in which the corresponding Dp-brane boundary state becomes the usual form, most of unstable D0-branes disappear by the tachyon condensation. Indeed, the remaining D0-branes consist the BPS D0-branes with the correct noncommutative coordinates as we can see in the fuzzy S^2 case explicitly. The noncommutativity appears because of the disappearance of the D0-branes by the condensation of the tachyon, which does not commute with the matrix coordinates.

The fuzzy S^2 brane corresponding to the D2-brane on S^2 with a unit flux should be built from one BPS D0-brane although a BPS D0-brane can not be fuzzy. We also show that the boundary state for the Dp-brane on the curved manifold which satisfies the Dirichlet boundary condition on the manifold is not localized on the manifold. Thus the D2-brane on S^2 with unit flux is equivalent to a BPS D0-brane even though it is at the origin. Here the D2-brane on S^2 means that it satisfies the Dirichlet boundary condition on the S^2, but it is at the origin.