Marginal Deformations and Classical Solutions in Open Superstring Field Theory[1]

High Energy Accelerator Research Organization (KEK) Isao Kishimoto
E-mail: `ikishimo@post.kek.jp`

String field theory (SFT) is known as a candidate for nonperturbative formulation of string theory. It is important to investigate it from various viewpoints and develop computational techniques in order to understand the whole aspect of string theory.

Here we have concentrated on Berkovits' open superstring field theory, which has Wess-Zumino-Witten like action in the Neveu-Schwarz sector, and constructed a class of classical solutions to the equation of motion: $\eta_0(e^{-\Phi}Q_{\rm B}e^{\Phi})=0$ in this framework, where string field Φ in the action has picture number 0 and is described in the large Hilbert space. In particular, one of our solutions: $\Phi_{0ij}=-\int_{C_{\rm left}}\frac{dz}{2\pi i}F_i(z)\tilde{v}(z)I\delta_{ij}$ represents a background Wilson line, where $\tilde{v}(z)\equiv\frac{1}{\sqrt{2}}c\xi e^{-\phi}\psi(z)$, $F_i(-1/z)=z^2F_i(z)$, $|I\rangle$ is the identity string field and i,j are Chan-Paton indices. We can show that the vacuum energy at this solution exactly vanishes: $S[\Phi_0]=\frac{1}{g^2}\int_0^1 dt\langle\langle\Phi_0\eta_0(e^{-t\Phi_0}Q_{\rm B}e^{t\Phi_0})\rangle\rangle=0$. The new BRST operator $Q'_{\rm B}$ around Φ_0 obtained by re-expanding the action $S[\Phi]$ as $e^{\Phi}=e^{\Phi_0}e^{\Phi'}$ can be rewritten as $Q'_{\rm B}=e^{\frac{i}{2\sqrt{\alpha'}}(X_L(F_i)+X_R(F_j))}Q_{\rm B}e^{-\frac{i}{2\sqrt{\alpha'}}(X_L(F_i)+X_R(F_j))}$, where $X_{L/R}(F_i)=\int_{C_{\rm left/right}}\frac{dz}{2\pi i}F_i(z)X(z)$. It implies that the original action is recovered by a field redefinition: $\Phi''_{ij}=e^{-\frac{i}{2\sqrt{\alpha'}}(X_L(F_i)+X_R(F_j))}\Phi'_{ij}$. Namely, the action has a relation $S[Q_{\rm B};\Phi]=S[Q_{\rm B};\Phi_0]+S[Q'_{\rm B};\Phi']=S[Q_{\rm B};\Phi'']$. Especially, noting $\Phi''_{ij}=e^{-\frac{i}{2\sqrt{\alpha'}}(f_i-f_j)\hat{x}_0+\cdots}\Phi'_{ij}$, where $f_i\equiv\int_{C_{\rm left}}\frac{dz}{2\pi i}F_i(z)$, this field redefinition induces a momentum shift: $p\to p-\frac{1}{2\sqrt{\alpha'}}(f_i-f_j)$. It is the same effect as a background Wilson line.

Including the Ramond sector, the equations of motion are proposed by Berkovits which have fermionic gauge symmetry generated by a parameter with picture number 1/2. We identified conventional on-shell global supersymmetry transformation from this gauge transformation and showed that our Wilson line solution is invariant under it.

The above solution which corresponds to Wilson line is based on a $U(1)$ supercurrent $\mathbf{J}(z,\theta)=\psi(z)+\theta\frac{i}{\sqrt{2\alpha'}}\partial X(z)$. This construction of solutions can be applied to general supercurrents $\mathbf{J}^a(z,\theta)=\psi^a(z)+\theta J^a(z)$ associated with some appropriate Lie group G. The obtained solutions to the equation of motion of super SFT should correspond to marginal deformations by J^a in terms of conformal field theory. Although the above arguments are restricted to GSO-projected theory, we can similarly construct a marginal solution in the GSO($-$) sector if a direction is compactified to S^1 with the critical radius because there exists an $SU(2)$ supercurrent. One of them represents a process such as non-BPS D-brane $\to$ D$\bar{\rm D}$ system.

[1]This talk is based on work in collaboration with Tomohiko Takahashi and the reference is `hep-th/0506240`.