Hadron Mass Spectroscopy by Spinning Strings

Presenter : Sachiko Terunuma (Ochanomizu univ.)
Collaborators : Masako Bando (Aichi univ.)
Akio Sugamoto (Ochanomizu univ.)

Introduction : We consider the spin-spin interaction in QCD-like String theory in order to study the hadron mass spectroscopy. We had studied meson masses without spin effect in QCD-like String theory at Prog. Theor. 112,323 (M. Bando et al.).

We set metric like this by referring to Iwasaki and Kikkawa's work (PRD8, 440, 1973).

$$g_{ab} \equiv \frac{1}{\alpha'}\partial_a X^\mu \partial_b X^\nu G_{\mu\nu}(x) + \frac{1}{2}[\bar{\psi}^\mu \gamma_a \mathcal{D}_b \psi^\nu - \mathcal{D}_b \bar{\psi}^\mu \gamma_a \psi^\nu] G_{\mu\nu}(x) \qquad \mathcal{D}_a \psi^\mu = \partial_a \psi^\mu + \partial_a X^\nu \Gamma^\mu_{\nu\lambda}(x)\psi^\lambda$$

fermionic term (which must contain spin-spin interaction)

with

$$ds^2 = f(u)(-dt^2 + dz^2 + d\mathbf{x}_\perp^2) + g(u)du^2 \qquad f(u) = (u/R')^{3/2}, \quad g(u) = (f(u)h(u))^{-1}$$

$$h(u) = 1 - (U_{KK}/u)^3$$

$$R'^3 = 2\pi\alpha_c N_c \alpha' / M_{KK}, \quad \text{and} \quad U_{KK} = \frac{8\pi}{9}\alpha_c N_c \alpha' M_{KK}$$

c.f. J. HEP 07 (2003) 049
M. Kurczenski et al.

Action is given as $S = \frac{\Delta t}{2\pi}\int dz\sqrt{-det g_{ab}}$ → energy E of string
(from AdS/CFT correspondence)

We choose $\sigma = z$ and $\tau = t$, and obtain conserved quantitie "energy" H, and solve ψ 's equation of motion.

$$u'(z) = \frac{2}{3}U_0^{\frac{3}{2}}\sqrt{(u(z)^3 - 1)(u(z)^3 - U_0^3)}$$ → This gives the shape of string.

$$\psi_\pm'^\perp = 0$$

$$\pm 2f^2\psi_\pm'^0 - (f + gu'(z)^2)(\partial_u f)\psi_\pm^5 = 0$$

$$2f\psi_\pm'^3 + (\partial u f)\psi_\pm^5 = 0$$

$$\pm(fg\psi_\pm'^5 + f(\partial_u f)\psi_\pm^3) + (f + gu'(z)^2)(\partial_u f)\psi_\pm^0 = 0$$

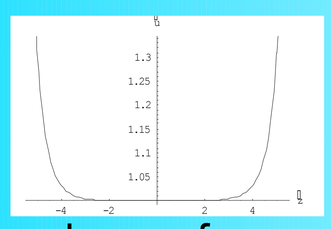
→ ψ 's equation of motion.

Then we use ψ 's boundary condition. $\psi^{0\sim3}$ is Neumann, ψ^5 is Dirichlet, so

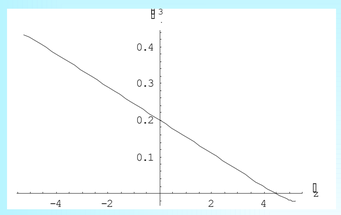
$$\psi_+^{0\sim3}(\pi) = \psi_-^{0\sim3}(\pi) \quad , \quad \psi_+^5(\pi) = -\psi_-^5(\pi) \qquad \text{with} \quad \psi^\mu = \begin{pmatrix}\psi_+^\mu \\ \psi_-^\mu\end{pmatrix}$$

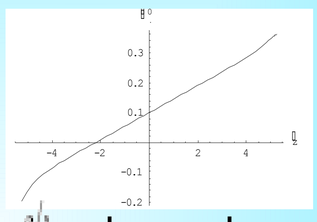
We treat our problem perturbatively , so the shape of string is not effected by ψ. But ψ ' s effects (spin-spin interactions) remain in the energy.

Conclusion

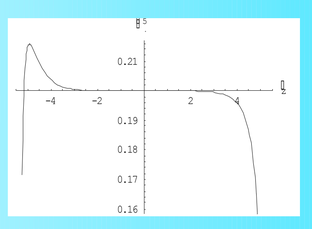


the shape of meson string





ψ depends on z



Energy E (z = 3.596 (GeV)^(-1))=0.66GeV with ψ
1.01GeV without ψ

ψ depends on z, and distributes over string.

Energy including ψ is different from the energy without ψ clearly .

In the future

We will consider the effect of ψ on string configuration which is neglected here.
We will calculate energy more accurately, and examine the spin effects in mass spectroscopy of hadrons.