Description of baryons in composite superconformal string model.

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Our aim and instrument

- Description of meson and baryon spectrum.
- Construction of interaction amplitude at low and intermediate energies (0,1 - 7 GeV).
- String has superconformal (gauge) symmetry (Super Virasoro algebra L_n, G_r).
- New type of string model.
  - Slope of Regge tajectories α' is about usual hadron scale $1 GeV^{-2}$.
  - Intercept α_0 of leading meson trajectory is equal to $\frac{1}{2}$.
  - New topology. Additional two-dimensional surfaces.
  - Supersymmetry occurs on two-dimensional world surface only. Target space does not have supersymmetry.

Description of fermions in this model

- Basic two-dimensional surface. ∂X_μ, H_μ, I, θ.
- Additional two-dimensional surfaces. $Y_\mu^{(i)}$, $f_\mu^{(i)}$, $J^{(i)}$, $\Phi^{(i)}$.
- Quark spinors and isospinors λ_i are represented by eigenvectors of zeroth component of field $J^{(i)}$. $J_0^{(i)}\lambda_i = \xi_i\lambda_i$.

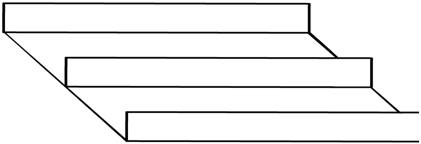
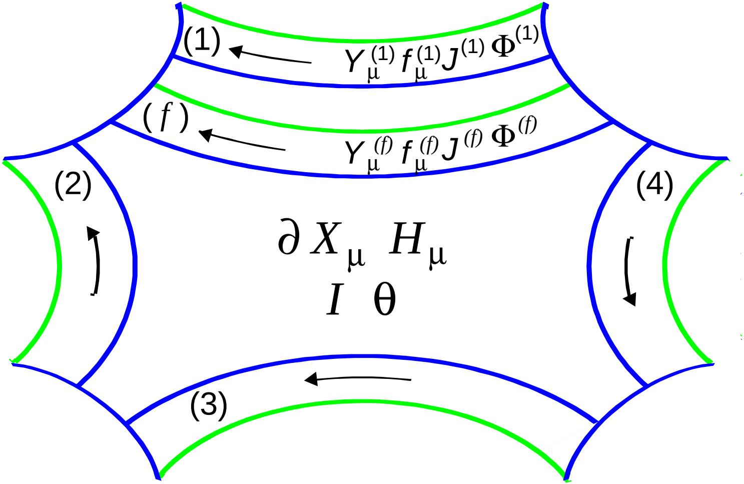


Figure: Composite string for baryon.

Direct amplitude



Vertex operator formalism

- Two-dimensional superconformal symmetry.
  Quantum super Virasoro algebra:

$$
\begin{aligned}
&[L_n, L_m] = (n-m)L_{n+m} + \delta_{n,-m} c_1 n(n^2-1),\\
&\{G_r, G_s\} = 2L_{r+s} + c_2\left(r^2 - 1/4\right)\delta_{r,-s},\\
&[L_n, G_r] = (n/2 - r)\, G_{n+r}.
\end{aligned}
$$

- We formulate vertex operator $\hat{V}$ of ground state emission which satisfies superconformal symmetry:

$$\hat{V}(z_i) = z_i^{-L_0}\left[G_r, \hat{W}\right] z_i^{L_0}, \quad \hat{W} \sim : e^{-ikX} : .$$

- We use formalism of vertex operator with conformal spin $J = 1$.
  $[L_n, \hat{V}_{J=1}] = \frac{d}{d\tau} z^n \hat{V}_{J=1}, \qquad z = e^{i\tau}$
- Additional supercurrent conditions to eliminate all negative norms from physical state spectrum.

$$[k_i Y_n^{(i)}, \hat{W}_{i,i+1}] = [\hat{W}_{i,i+1}, k_{i+1} Y_n^{(i+1)}] = 0.$$

Spin and isospin structure

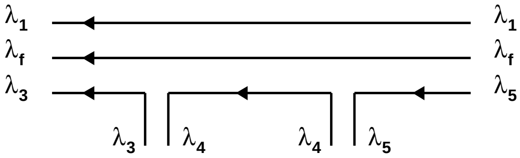


Figure: Schematic π N interaction diagram.

- Interaction amplitude for π-meson and nucleon:
$$A_{\pi N} = \int dz \langle 0| \hat{V}_N \hat{V}_\pi \hat{V}_\pi \hat{V}_N |0\rangle.$$
- Spin structure
  - π-meson spin-parity 0^-: $(\lambda_3 \gamma_5 \lambda_4)$
  - Nucleon spin-parity $\frac{1}{2}^+$:
    $V_N^{(NS)}$: $(\lambda_1 \gamma_5 \lambda_3) \lambda_f \gamma_5$, $V_N^{(BH)}$: $(\lambda_1 \lambda_3) \lambda_f$,
- Isospin structure
  - π-meson isospin $T = 1$: V_π : $\lambda_3 \tau^{(i)} \lambda_4$.
  - Nucleon isospin $T = \frac{1}{2}$: V_N : $(\lambda_1 \lambda_3) \lambda_f$

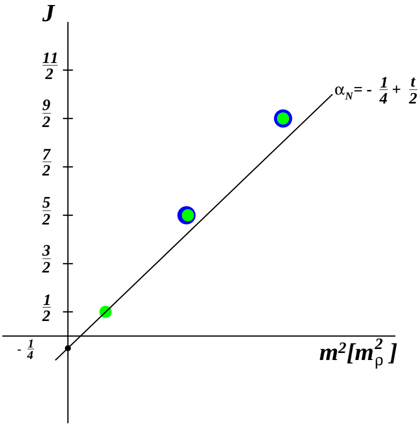
Interaction amplitude of π meson and nucleon

For pole contributions in t-channel near pole values $t = m_i^2$ (mass condition $L_0 = 1$) we can consider direct interaction amplitude of πN:

$$A_{\pi N} \sim \Pi_+(t)\frac{\Gamma(\frac{1}{2} - \alpha_{N^+}(t))\Gamma(1 - \alpha^\rho(s))}{\Gamma(\frac{3}{2} - \alpha_{N^+}(t) - \alpha^\rho(s))} + \Pi_+(t)\frac{\Gamma(\frac{3}{2} - \alpha_{\Delta^-}(t))\Gamma(1 - \alpha^\rho(s))}{\Gamma(\frac{3}{2} - \alpha_{\Delta^-}(t) - \alpha^\rho(s))} +$$
$$+\Pi_-(t)\frac{\Gamma(\frac{3}{2} - \alpha_{\Delta^+}(t))\Gamma(1 - \alpha^\rho(s))}{\Gamma(\frac{3}{2} - \alpha_{\Delta^+}(t) - \alpha^\rho(s))} + \Pi_-(t)\frac{\Gamma(\frac{3}{2} - \alpha_{N^-}(t))\Gamma(1 - \alpha^\rho(s))}{\Gamma(\frac{3}{2} - \alpha_{N^-}(t) - \alpha^\rho(s))}.$$

Where
$\alpha_{N^+}(t) = -\frac{1}{4} + \frac{t}{2}$, $\alpha_{N^-}(t) = -\frac{1}{4} + \frac{t}{2}$,
$\alpha_{\Delta^+}(t) = \frac{1}{4} + \frac{t}{2}$, $\alpha_{\Delta^-}(t) = -\frac{3}{4} + \frac{t}{2}$.

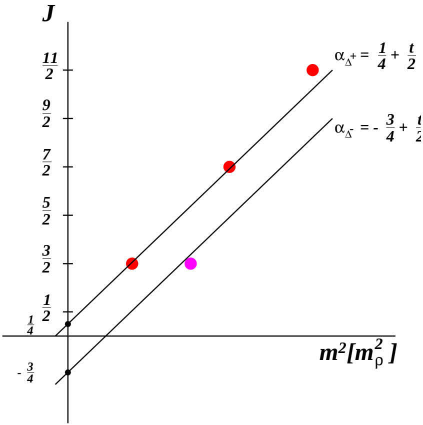
N Regge trajectories



Green dots: $m(\frac{1}{2}^+) = 940\,MeV$, $m(\frac{5}{2}^+) = 1680\,MeV$, $m(\frac{9}{2}^+) = 2250\,MeV$.

Blue dots: $m(\frac{5}{2}^-) = 1675\,MeV$, $m(\frac{9}{2}^-) = 2220\,MeV$.

Δ Regge trajectories



Red dots: $m(\frac{3}{2}^+) = 1232\,MeV,\ m(\frac{7}{2}^+) = 1950\,MeV,\ m(\frac{11}{2}^+) = 2420\,MeV.$

Violet dot: $m(\frac{3}{2}^-) = 1700\,MeV.$

Conclusions

- The model gives nondegenerate in parity fermion Regge trajectories.
- It is a new type of string model.
- The leading meson trajectory has the intercept $1/2$.
- Supersymmetry conditions are satisfied on the two-dimensional surface only.
- Physical spectrum of states is free from ghosts.

Thank you

Projectors on parity

- λ contains numerical spinor u, satisfying Dirac equation:

$$\hat{P}_f u^{(+)} = m u^{(+)}, \qquad \hat{P}_f u^{(-)} = -m u^{(-)}.$$

$$\sum \bar{u}_\alpha^{(i)+} u_\beta^{(i)+} + \sum \bar{u}_\alpha^{(i)-} u_\beta^{(i)-} = \left(\frac{m+\hat{q}}{2m}\right)_{\alpha\beta} + \left(\frac{m-\hat{q}}{2m}\right)_{\alpha\beta} = 1.$$

- Initial state chooses $P_f = +1$ or $P_f = -1$.
- For each pole arises projector:

$$\Pi_+ = \frac{m+\hat{q}}{2m}, \qquad \Pi_- = \frac{m-\hat{q}}{2m}.$$

- For arbitrary q we suggest analytic continuation:

$$\frac{m \pm \hat{q}}{2m} \to \frac{1}{2}\left(1 \pm \frac{\hat{q}}{\sqrt{2(R-L_0)}}\right) \to \left(\frac{1}{2} \pm \frac{\hat{q}}{\sqrt{\pi}} \int_0^\infty dy \; e^{-2(R-1)y^2}\right).$$

- We used: $L_0 = -\frac{q^2}{2} + R$, and mass condition $L_0 = 1$.