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@素核宇融合による計算物理学の進展（合歓の郷）

Superstring and Nucleus
超弦理論と原子核

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Under discussions with :
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Lattice alternative?

Result 1 : Matrix description of multi baryons

2010

arXiv/1003.4988 N. Iizuka, P.Yi, KH

arXiv/1005.4412, 1006.3612 N. Iizuka, KH

Result 2 : Formation of nucleus

2011

arXiv/1103.5688 T. Morita, KH

Ambitions : Nuclear matter, neutron star

2012

Result 1 : Nucleus = Matrix

AdS/CFT correspondence

Large N_c QCD
strong coupling

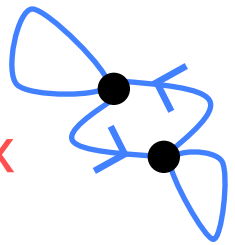
$\simeq$

String theory
in curved geometry

Nucleus is a matrix

Baryon : heavy at large N_c
= D-brane

Multiple D-branes
described by matrix



Result 1 : M-theory for Nuclear Physics?

[Iizuka,Yi, KH 1003.4988]

$$S = c \int dt \ \mathrm{tr} \left[\frac{1}{2} (D_t X^I)^2 - \frac{g^2}{4} [X^I, X^J]^2 \right] + \cdots$$

$X^M \ (M = 1, 2, 3, 4)$: *A* x *A* Hermitian matrix

$X^{M=1,2,3}$ eigenvalues = *A* baryons' location

Only 2 parameters : $M_{\mathrm{KK}}, \ \lambda \equiv N_c (g_{\mathrm{QCD}})^2$

Nuclear physics

$$S \sim \int dt \left[\sum_{i=1}^{A} \frac{1}{2} m_N |\partial_t \vec{x}^{(i)}|^2 + \sum_{i \neq j} V(x^{(i)} - x^{(j)}, \cdots) + \cdots \right]$$

Result 2 : Solve heavy nucleus

[Morita, KH 1103.5688]

Large A : Dimensionally reduced Yang-Mills

$$S = c \int dt \ \mathrm{tr} \left[\frac{1}{2} (D_t X^I)^2 - \frac{g^2}{4} [X^I, X^J]^2 \right]$$

Question :

Solve this quantum mechanics at large A.

Bound state?

Nuclear radius ? $\sqrt{r^2_{\mathrm{mean}}} \equiv \sqrt{\frac{1}{A} \mathrm{tr} \langle X^I X^I \rangle}$

Result 2 : Analytic formula for the Radius

[Morita, KH 1103.5688]

Use large D, large A expansion （ $g^2 A D$ fixed ）

$$\sqrt{r^2_{\rm mean}}\Big|_{T=0} = \frac{3^{5/2}\pi^{2/3}}{2^{5/6}5^{1/6}} \frac{A^{1/3}}{M_{\rm KK}(N_c\lambda^2)^{1/3}}$$

Input :
- Rho meson mass $M_{\rm KK} \sim 0.95[\mathrm{GeV}]$
- Yukawa $g_{\pi NN}$ $\lambda \sim 5.3$

$$\sqrt{r^2_{\rm mean}} \sim 0.7 A^{1/3}\ [\mathrm{fm}]$$

Experiments : $\sqrt{r^2_{\rm mean}} \simeq 1.0 A^{1/3}\ [\mathrm{fm}]$

Ambitions : Nuclear matter, Neutron star