Nucleon isovector couplings from lattice QCD at the physical point

Tsukamoto Natsuki

19/05/08

Collaborators

- E. Shintani (Riken)
- Y. Aoki (Riken)
- K.-I. Ishikawa (Hiroshima Univ.)
- Y. Kuramashi (Univ. of Tsukuba)
- S. Sasaki (Tohoku Univ.)
- T. Yamazaki (Univ. of Tsukuba)

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He had quit physics! I had succeed to some of the his work.

Nucleon couplings/form factors

The nucleon matrix elements of the bilinear operator are affected by the QCD correction.

$$\langle N|\overline{q}\Gamma q|N\rangle \sim g_\Gamma \overline{u}_s \Gamma u_s$$

charge	operator	interest	precision(expr.)
vector	$\overline{q}\gamma_\mu q$	proton size	few % level(radius)
axial	$\overline{q}\gamma_5\gamma_\mu q$	neutron life time	sub-percent level
tensor	$\overline{q}\sigma_{\mu\nu} q$	neutron EDM	$>50\%$ level
(p)scalar	$\overline{q}(\gamma_5) q$	TeV scale coupling	N/A

We can also access the information of the charge distribution via the coupling as a funtion of the momentum transfer, form factor.

Nucleon form factor/couplings using PACS10 Conf.

PACS performed the realistic simulation using PACS10 Conf.

PACS10 Gauge Configuration

- physical pion mass ($m_\pi = 135\mathrm{MeV}$)
- large volume $(10.8\mathrm{fm})^3$
  - $L^3T = 128^4$ generated
  - $L^3T = 160^4$ generated
  - $L^3T = 256^4$ on-going?
- We are free from the systematics error!

https://www.itmedia.co.jp/news/articles/1711/20/news134.html

Achivement ($L^3T = 128^4$)

- accurate determination of g_A
- few-percent determination of the proton radius

PRD 99 014510(2019) Actually I'm not concerned with this work.

Our prospect

- More precise/accurate determination
  - more measurements
  - measurements in the fine lattice
- non-standard nucleon coupling
  - scalar
  - tensor (renormalization required!)
- non-local nucleon coupling
  - quark helicity operator (renormalization required!)
  - quark momentum fraction operator (renormalization required!)
- three-quark operator
  - nucleon decay operator (renormalization required!)

Althought there are many thing to do, we want to reveal the any property of the nucleon. The renormalization constant is strongly required!!!

What I have to do?

- computing the nucleon correlators using existing code
  for more accurate/precise determination
- computing the renormalization constant
  for the non-standard, non-local or three quark operators
- analyzing the raw data

Computer Resource

- LX 406Re-2 in Tohoku Univ.
- Oakforest PACS in JCAHPC (U. of Tokyo, U. of Tsukuba)
- Cygnus(sigunasu? kigunasu?) in U. of Tsukuba

Schedule

- Writing up the paper for the old study until the end of May
- Oral presentation in Lattice 2019 (Wuhan/Bukan) June
- ECT* TALENT School 2019 July-August (not confirmed)

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Toward the doctoral thesis

- necessary
  - more accurate/precise determination of nucleon form factors
  - non-standard nucleon couplings such as tensor and scalar couplings
- not necessary I think
  - nucleon non-local matrix elements, structure functions
  - three-quark operators, nucleon decay
- I don't want to think about
  - hyperon decay, f_3, g_2 form factors