The Strangeness and Charmness of Nucleon and the Roper Mass From Chiral Fermions

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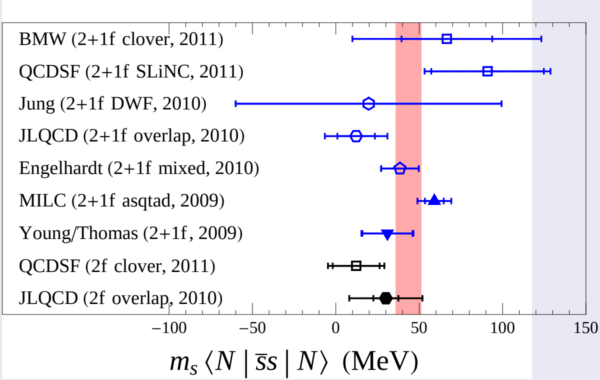
Outline

Strangeness and Charmness of Nucleon

Recent results on the strangeness

$$f_{T_s} = \frac{m_s \langle N|\bar{s}s|N\rangle}{m_N}$$

$$f_{T_c} = \frac{m_c \langle N|\bar{c}c|N\rangle}{m_N}$$



[a]

[a] Huey-Wen Lin, arXiv:1112.2435v1 [hep-lat]

Valence overlap fermions on 2+1 flavor domain wall fermion configurations

- Chiral symmetry
- Small $O(a^2)$ and $O(m^2 a^2)$ errors
- Small Δ_{mix}

- Deflation and HYP smearing algorithm
- Multi-mass algorithm
  - Speed up 79 times for $32^3 \times 64$ lattices
  - Speed up 51 times for $24^3 \times 64$ lattices [a]

[a] A. Li et al., Phys.Rev.D82:114501,2010

Improvements for nucleon correlation functions

Improving the signal of nucleon 2-pt functions

- **Double sources** – Sources on $t = 0$ and $t = 32$ simultaneously
- Z_3 **grid source** – A grid of point sources with Z_3 noise phases
- **Low-mode substitution** – Low modes part is treated exactly
- **Smearing** – optimized interpolation field

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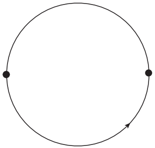

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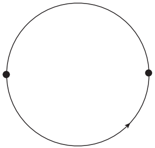

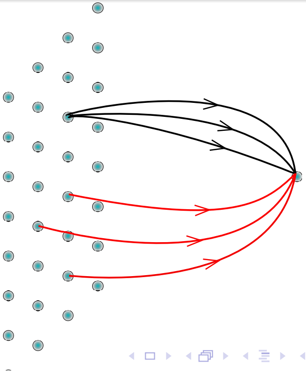

Improvements for loops

Improving the signal of loops

- Z_4 **noise source**
- **Grid and dilution technique** – The sources are diluted to even-odd grid with cell $(4, 4, 4, 2)$
- **Low-mode average** – Low modes part is treated exactly

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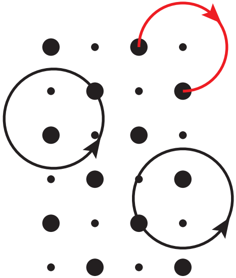
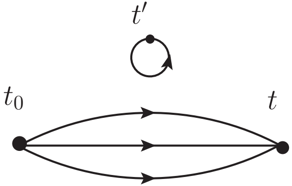


The plateau of disconnected 3-pt functions

$$R(t', t, t_0) = \frac{< N(t)\bar{s}s(t')\bar{N}(t_0) > - < N(t)\bar{N}(t_0) >< \bar{s}s(t') >}{< N(t)\bar{N}(t_0) >}$$

$$\langle N|\bar{s}s|N\rangle = \lim_{\substack{t'-t_0\to\infty \\ t-t'\to\infty}} R(t', t, t_0)$$



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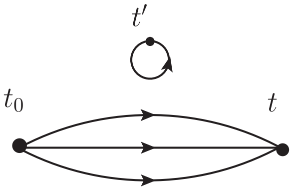
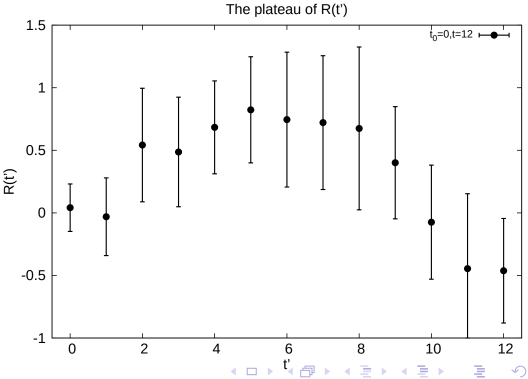


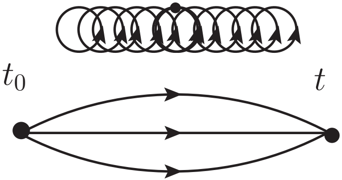


The slope technique for disconnected 3-pt functions

$$R'(t, t_0) = \sum_{t'=t_0+1}^{t-1} R(t', t, t_0)$$

We can do the fitting :

$$R'(t, t_0)\,|_{t\to\infty} = const. + t\,\langle N|\bar{s}s|N\rangle$$



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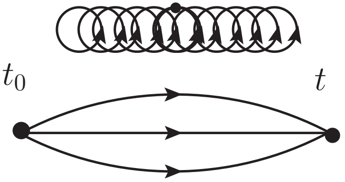
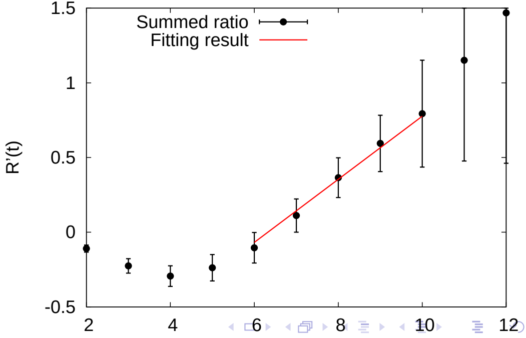
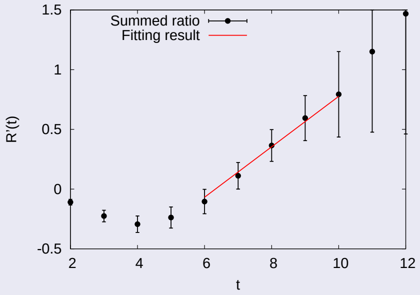


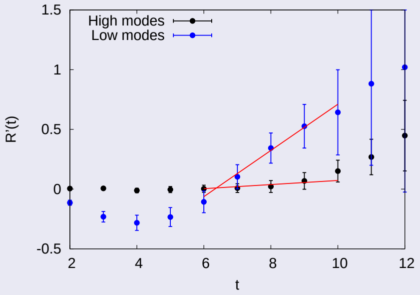


The simulation parameters

Lattice size	$24^3 \times 64$
Lattice spacing	$1/a = 1.73(3)$ GeV
$m_{ud}^{(sea)}$	0.005
$m_s^{(sea)}$	0.04
$m_\pi^{(sea)}$	≈ 331 MeV
Number of configurations	128

The strangeness of nucleon



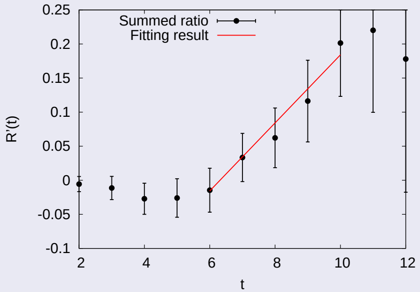


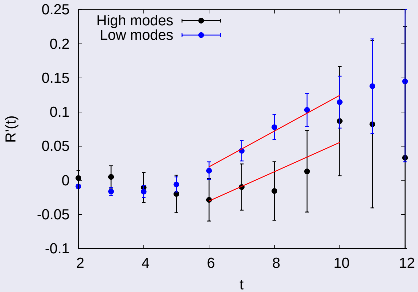
The fitting result

For $m_s = 0.063,\ m_{ud} = 0.016$ case :

$f_{T_s} = 0.0205(44)$, ${f_{T_s}}^L = 0.0187(41)$, ${f_{T_s}}^H = 0.0017(15)$

The charmness of nucleon



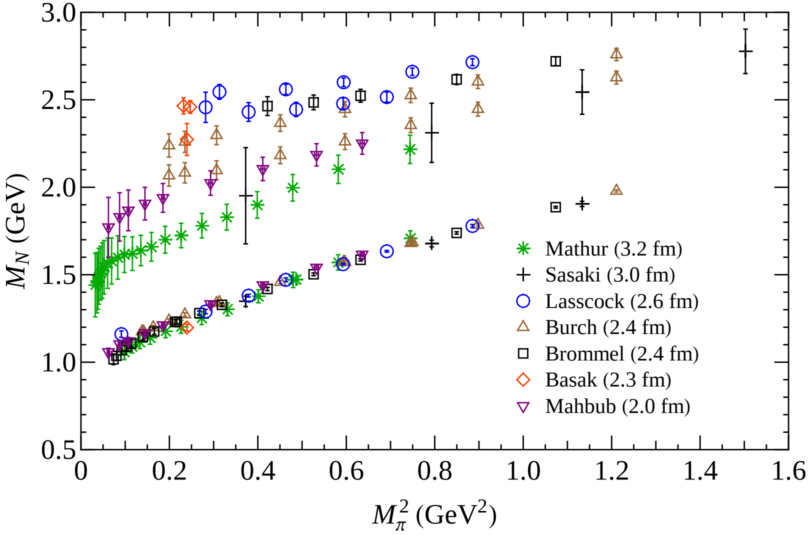


The fitting result

For $m_c = 0.73$, $m_{ud} = 0.016$ case :

$f_{T_c} = 0.056(18)$, ${f_{T_c}}^L = 0.029(6)$, ${f_{T_c}}^H = 0.024(17)$

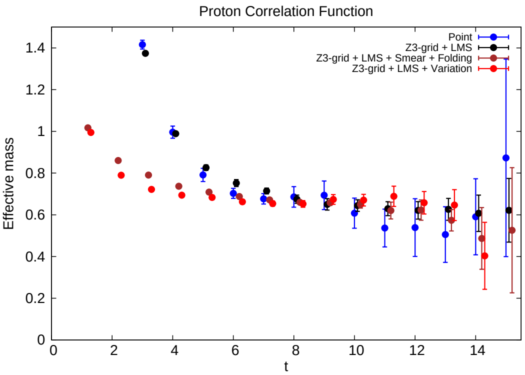
The Roper mass from quenched studies



Comparison for the improvements for proton

Lattice settings

Lattice size : $24^3 \times 64$, $m_{ud}^{(sea)} = 0.005$, $m_s^{(sea)} = 0.04$, $m_\pi \approx 305\text{MeV}$
47 DWF configurations are used



Point source

$m_{proton} = 1.13(14)\text{GeV}$

Grid with LMS

$m_{proton} = 1.08(5)\text{GeV}$

Smeared Grid with LMS

$m_{proton} = 1.14(2)\text{GeV}$

Variation

$m_{proton} = 1.12(1)\text{GeV}$

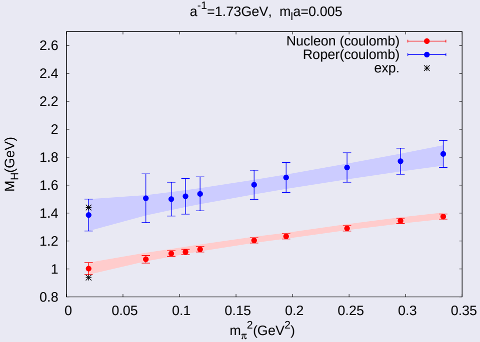
The Roper from wall source with coulomb gauge fix

Lattice settings

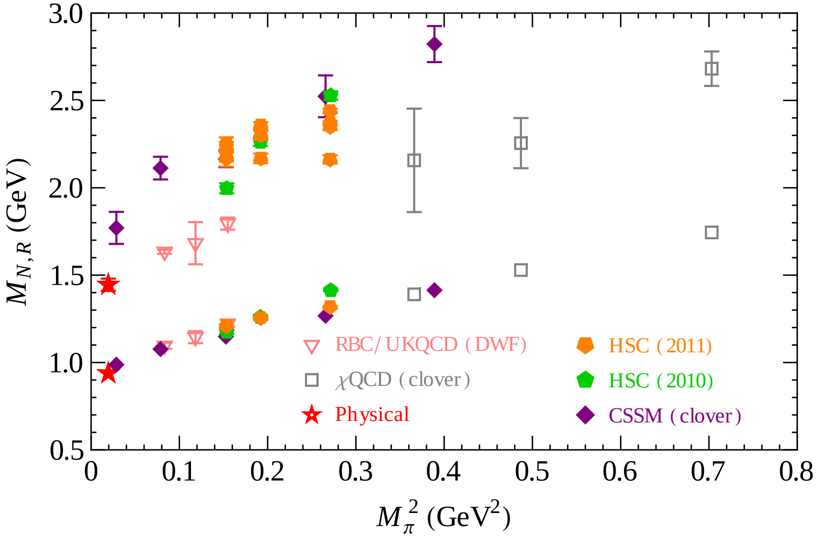
Lattice size : $24^3 \times 64$, $m_{ud}^{(sea)} = 0.005$, $m_s^{(sea)} = 0.04$
51 DWF configurations are used

The chiral extrapolation

$$\begin{aligned} M_N(m_v) &= M_N(0) \\ &+c_1 m_{ps}(m_v, m_v)^2 \\ &+c_2 m_{ps}(m_v, m_s)^3 \end{aligned}$$



The Roper from other groups with dynamical fermions



Conclusion

- The strangeness and charmness of nucleon are calculated.
  - The low-mode-substitution technique on proton and the low-mode-average technique on loop are very helpful.
  - From one ensemble, we get $f_{T_s} = 0.0205(44)$ and $f_{T_c} = 0.056(18)$.
  - The data on other ensembles are being calculated and the chiral and continuum extrapolation will be done.
- The Roper mass is calculated.
  - Our results are consistent with the experimental value and with the earlier quenched overlap study.
  - The wall source on coulomb gauge fixed configurations can suppress the p-wave scattering states very much.
  - The scattering states is being carefully checked with the spectrum in ρ meson channel.
  - The data on other ensembles are being calculated and the full chiral and continuum extrapolation will be done.

Thank you !