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受理番号 Proposal No.	大型 10-14	研究課題名 Program title	格子 QCD による核力の研究	

研究を終了しましたので、下記の通り報告します。

成果の概要

Abstract

(和文) 格子 QCD により核力・ハイペロン力の研究を進めている。Luescher の方法を拡張し、Nambu-Bethe-Salpeter 波動関数の長距離の漸近形に注目することで、散乱データに忠実な現実的核力を格子 QCD で理論的に構築できる。この方法を様々な状況に拡張して、核力だけでなくハイペロン力や三核子間力にも応用している。ハイペロン力の研究では、2+1 flavor PACS-CS ゲージ配位 ($m_{\pi}=700$ MeV) を用いて $\Lambda\Lambda - N\Xi - \Sigma\Sigma$ 結合系 ($I=0$)、 $N\Lambda - N\Sigma$ 結合系 ($I=1/2$)、 $N\Sigma$ 系 ($I=3/2$) の (結合チャンネル) ハイペロン力の計算を行った。J-PARC におけるハイペロン力の実験的決定と相まって、格子 QCD によるハイペロン力の生成は注目されている。一方で 2 flavor CP-PACS ゲージ配位を用いた三核子間力の計算を進めた。三核子間力の計算は計算量が膨大になるので、三つの核子が一直線に並ぶ linear setup を採用して進めている。三核子間力は現象論的決定が困難だが、様々な局面で現象論的に重要な役割を果たし、格子 QCD で求められるようになることが切望されている。

(英文) We study the nuclear forces and the hyperon forces by using lattice QCD. By extending Luescher's finite volume method for the scattering phase, and by utilizing the asymptotic behavior of the Nambu-Bethe-Salpeter wave functions, it is possible to calculate nuclear forces, which are faithful to scattering data. We extend our method to varieties of targets such as the hyperon forces and three nucleon forces. To study hyperon forces, we use 2+1 flavor PACS-CS gauge configurations ($m_{\pi}=700$ MeV) to obtain coupled channel interactions in $\Lambda\Lambda - N\Xi - \Sigma\Sigma$ coupled system ($I=0$), $N\Lambda - N\Sigma$ coupled system ($I=1/2$) and $N\Sigma$ system ($I=3/2$). Related to the experimental determination of hyperon forces at J-PARC, it is important to perform lattice QCD calculation of hyperon forces. The three nucleon force is studied by using 2 flavor CP-PACS gauge configurations. In order to reduce the enormous numerical costs, we restrict ourselves to the linear setup, where three nucleons are aligned on a straight line. Three nucleon force is expected to play important roles in varieties of phenomena. However, experimental determination of three nucleon force is difficult. It is therefore important to perform 1st principle calculations based on the lattice QCD to unveil the nature of the three nucleon force.

研究成果を公開しているホームページアドレス

研究成果の 公表	口頭研究発表 件数	査読付きの学術論文数	プロシーディング論 文数	その他 (投稿中を含 む)
	12	4	7	2

口頭研究発表

1. T. Doi, for HAL QCD Collaboration,
``Exploring Three Nucleon Forces in Lattice QCD"
``12th International Conference on the structure of baryons (Baryons'10)",
Osaka, Japan, 7-11 Dec. 2010.
2. T. Doi, for HAL QCD Collaboration (plenary talk)
``Exploring Two and Three Nucleon Forces in Lattice QCD"
International Symposium on ``From Quarks to Supernovae", Atagawa, Japan, 28-30 Nov. 2010.
3. T. Doi, for HAL QCD Collaboration (invited talk)
``Hadron-Hadron Interactions from Lattice QCD"
International conference on ``Nucleon-Nucleon Interaction and Nuclear Many-Body Problem",
Mumbai, India, 18-27 Nov. 2010.
4. Keiko Murano, Sinya Aoki, Tetsuo Hatsuda, Noriyoshi Ishii, Hidekatsu Nemura,
``The non-locality of the nucleon-nucleon potential from Lattice QCD",
From Quark to Supernova, Sizuoka, Japan, 28-30 Nov 2010.
5. H. Nemura, (for HAL QCD Collaboration),
"Lambda-nucleon potential calculated from lattice QCD",
The International Conference on the Structure of Baryons
(BARYONS'10), Osaka, Japan, December 7 - 11, 2010.
6. H. Nemura, (for HAL QCD Collaboration),
"Lattice QCD study of hyperonic interactions",
The 3rd GCOE International Symposium on
"Weaving Science Web beyond Particle-Matter Hierarchy",
Sendai, Japan, February 17 - February 19, 2011.
7. Sinya AOKI,
``Nuclear Force from lattice QCD and its extensions",
MLL-colloquium, October 21, 2010, TU, Munich, Germany
8. Noriyoshi Ishii for HAL QCD Collaboration, (invited talk)
``Hadron interactions from lattice QCD"
QCD meets Nuclear Physics, TRIUMF, Vancouver, Canada, November 4-5, 2010.
9. Noriyoshi Ishii for HAL QCD Collaboration, (invited talk)
``Nuclear Forces from Lattice QCD"
International Symposium ``New Faces of Atomic Nuclei", An EFES/OIST contribution, Okinawa
Institute of Science and Technology (OIST), Okinawa, Japan, November 15-17, 2010.
10. Noriyoshi Ishii for HAL QCD Collaboration, (invited talk)
``NN interaction from the lattice"
International conference on the structure of baryons, BARYONS'10,
RCNP, Osaka, Japan, December 7-11, 2010.
11. Tetsuo Hatsuda (plenary talk)
``From Yukawa and Nambu to Lattice Nuclear Force: a modern perspective on the longstanding
problem"
International conference on the structure of baryons, BARYONS'10,
RCNP, Osaka, Japan, December 7-11, 2010.

12.

Kenji Sasaki for HAL QCD Collaboration,

“Hyperon-hyperon interaction from lattice QCD through the coupled channel formalism”

KEK 理論センター研究会「ストレンジネス 2010」, Tsukuba, Japan, December 2-4, 2010.

査読つきの学術論文(URL を記載)

1. Takashi Inoue, Noriyoshi Ishii, Sinya Aoki, Takumi Doi, Tetsuo Hatsuda, Yoichi Ikeda, Keiko Murano, Hidekatsu Nemura, Kenji Sasaki,
Prog. Theor. Phys. **124**, 591 (2010).
“Baryon-Baryon Interactions in the Flavor SU(3) Limit from Full QCD Simulations on the Lattice”
2. Takashi Inoue, Noriyoshi Ishii, Sinya Aoki, Takumi Doi, Tetsuo Hatsuda, Yoichi Ikeda, Keiko Murano, Hidekatsu Nemura, Kenji Sasaki,
Phys. Rev. Lett. **106**, 162002 (2011).
“Bound H-dibaryon in Flavor SU(3) Limit of Lattice QCD”
3. Keiko Murano, Noriyoshi Ishii, Sinya Aoki, Tetsuo Hatsuda,
Prog. Theor. Phys. **125** (2011) in press (2011 年 6 月)
“Nucleon-Nucleon Potential and its Non-locality in Lattice QCD”
4. Noriyoshi Ishii,
Few Body Syst. **49**, 269 (2011).
“Lambda-nucleon and nucleon-nucleon interactions on the Lattice”

プロシーディング論文(URL を記載)

1. T. Doi, for HAL QCD Collaboration,
“The study of the Three Nucleon Force in full QCD Lattice calculations”
PoS LAT2010, 136 (2010), arXiv:1011.0657 [hep-lat].
2. K.Murano, N.Ishii, S.Aoki, T.Hatsuda,
“Non-locality of the nucleon-nucleon potential from Lattice QCD”.
PoS LAT2010, 150 (2010).
3. H. Nemura, (for HAL QCD Collaboration),
“Lattice QCD towards nuclear forces”,
Proceedings of the 21st European Conference on Few-Body Problems,
Few-Body Systems (in press, online version is available from
<http://dx.doi.org/10.1007/s00601-011-0215-z>)
4. Sinya Aoki,
“Recent progress on nuclear potentials from lattice QCD”,
(arXiv:1011.5572[hep-lat])
Proceedings of the 35th International Conference of High Energy Physics –ICHEP2010

5. Noriyoshi Ishii for HAL QCD Collaboration,
“An extension to the Luscher’s finite volume method above inelastic threshold (formalism)”
PoS LAT2010, 145 (2010).
6. Kenji Sasaki for HAL QCD Collaboration,
“Coupled Channel Approach to $(S,I) = (-2,0)$ Baryon-Baryon Interactions from Lattice QCD”,
Proceedings fo the 21st European Conference on Few-Body Problems, (arXiv:1012.5684v1[nucl-th]).
7. Kenji Sasaki for HAL QCD Collaboration,
“Lattice QCD study of baryon-baryon interactions in the $(S,I)=(-2,0)$ system using the
coupled-channel formalism”
PoS LAT2010, 157 (2010).

その他（学位論文、紀要、投稿中の論文を含む）（URL を記載）

特記（本研究に関係した、新聞記事・著作、受賞など）

1. 受賞
Keiko Murano,
Best Poster Award, International Symposium “From Quarks to Supernovae”
November 30, 2010, Atagawa, Japan
2. 新聞発表
2011年4月21日
スーパーコンピュータが捉えたクォーク6個からなる粒子「H-ダイバリオン」
日本経済新聞、東京新聞、茨城新聞をはじめとする新聞各社に掲載された。