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| 著者(和文) | CanKadir Utku |
| Author(English) | Utku Can |
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# 論 文 要 旨

THESIS SUMMARY

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| 学生氏名：<br>Student's Name | CAN KADIR UTKU | 指導教員（主）：<br>Academic Advisor(main) | 岡 真 |
| | | 指導教員（副）：<br>Academic Advisor(sub) | 伊藤 克司 |

要旨（英文 800 語程度）
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In this thesis, the "*Electromagnetic Form Factors of Charmed Baryons in Lattice QCD*", we evaluate the electromagnetic form factors and masses of charmed baryons numerically by utilizing the non-perturbative lattice QCD method. Composite nature of a particle can be probed by electromagnetic interactions and, from a theoretical point of view, information about their structure is embedded into form factors. Studying the electromagnetic form factors would reveal information about charge distributions and magnetic or higher moments of the hadrons in question. Most of the experimental and theoretical efforts on baryon electromagnetic form factors have been focused on nucleon while the data on charmed sectors is limited to its spectroscopy. Forthcoming experiments with a heavy-hadron physics programme at major experimental facilities, *e.g.* J-PARC, SuperKEKB, BES-III *etc.*, are expected to provide a wealth of information on charmed baryons, which calls for a better understanding of the heavy-sector dynamics from theoretical grounds.

After the introduction, in the first part of Chapter 2, we give the QCD formalism and discuss the hadron structure by a brief historical account. Second part focuses on the lattice approach, where we investigate its implementation in detail. We discuss the discretization of the space-time and the QCD action and sketch its application.

Technical details are given Chapter 3. In a nutshell, we have run our simulations on PACS-CS generated lattices of $(32a)^3 \times 64a$ in size with a lattice spacing of $a = 0.0907(13)$ fm. We have utilized five sets of gauge ensembles incorporating the dynamical effects of *u/d* and *s* quarks with varying light-quark masses corresponding to a range of $m_\pi \approx 700$-156 MeV and with strange and charm quark masses fixed to their respective physical values.

Our results on the electromagnetic observables of charmed baryons are presented and discussed in detail along with comparisons to the light sector and results of the other methods in Chapter 4. We extract the masses and corresponding electromagnetic observables of spin-1/2 charmed baryons on four sets of gauge ensemble to investigate their light-quark mass dependence. Observables of spin-3/2 charmed-strange baryons have been extracted on lightest pion-mass ensemble only since they contain no valence light quark. Mass of the singly charmed $\Sigma_c$ baryon is found to be in good agreement with the experimental result when a chiral form is used. Masses of the doubly charmed $\Xi_{cc}$ and charmed-strange baryons on the physical point are overestimated slightly with respect to either their experimental values or other lattice groups' determinations. However, no visible effect has been identified on form factor results due to this small discrepancy.

Static properties, such as electric charge radii, magnetization densities and the magnetic and higher order moments of the baryons are extracted. We found that the charmed baryons are compact – the magnitude of their observables is decreased – compared to their light-sector counterparts. An investigation of individual quark contributions reveals that the decrease is caused by the reduced contribution of the charm quark — charge distribution of the lighter quarks is larger than that of charm quark. Flavor or spin composition of the baryons have been found to have minimal effect on their electromagnetic properties. We could isolate a non-zero value for the electric-quadrupole moments of spin-3/2 $\Omega_{cc}^*$ and $\Omega_{ccc}$ baryons, indicative of a distorted shape for their electric charge distributions and involvement of the tensor force.

Magnetic moments are found to be smaller compared to that of their light counterparts due to the charm quarks as well. Doubly represented quark sectors found to have dominant role on determining the magnetic moment of the baryon. Contributions of the individual quarks to the total magnetic moment of the baryon are observed to be enhanced in spin-3/2 configurations.

Moments of $\Omega_c(1/2^+)$ and $\Omega_c^*(3/2^+)$ found to be similar, consonant with the heavy-quark spin symmetry expectations. We have analyzed the possible sources of systematic errors such as excited state contributions, discretization or finite volume effects and showed that they are under control.

This work has provided the first systematic lattice QCD study of the electromagnetic form factors of charmed baryons as a part of our current wider program. Future calculations progress along extracting further phenomenologically relevant observables related to the charmed baryons with the hope that it will help improve our understanding of the structure and interactions of heavy-flavored baryons from first principles.