
Nonperturbative Aspects of Kaon Structure

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Signed Statement

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

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Adelaide, 12 January 2016.
Sincerely Yours,

PARADA TOBEL PARADUAN HUTAURUK, M.Sc

Dedication

*Tetapi firman ini sangat dekat kepadamu, yakni di dalam mulutmu,
dan didalam hatimu, untuk dilakukan*

(Ulangan 30:14) [ITB]

*But the word is very nigh unto thee, in thy mouth, and in thy heart,
that thou mayest do it*

(Deuteronomy 30 :14) [KJV]

Kupersembahkan untuk:

*Ayahanda dan ibunda tersayang (St. R. Hutauruk dan M. Br. Hutabarat)
Isteriku tercinta (Eva Dina Sakti) dan anak-anakku tersayang (Tania dan Atta),
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Abstract

In this thesis we have studied the structure of the kaon using the Nambu-Jona-Lasinio (NJL) model with the proper-time regularisation scheme to simulate the effect of quark confinement. The separate contributions of each flavour to the elastic form factor are calculated with and without the effect of dressing at the quark-photon vertex. In comparison with the existing experimental data, our model shows a remarkable agreement. We found the contribution of the anti-strange quark sector form factor of the kaon dominates for $Q^2 \geq 1.6 \text{ GeV}^2$, whereas the contribution of the u -quark sector form factor of the kaon is larger for $Q^2 \leq 1.6 \text{ GeV}^2$. Clearly the difference in quark masses leads to a dramatic difference between the anti-strange quark and the up quark contribution to the kaon form factors.

We observed the structure of the kaon with a particular interest in the effects of the larger mass of the strange quark. At present, a detailed understanding of the pion and kaon structure is hampered by the rather small sample of experimental data. It is known that u_K is somewhat softer than u_π in large- x valence region, which we will show is a natural consequence of the larger mass of the spectator strange quark in the K^+ . While at the present time, one does not know the separate flavor contributions to the kaon elastic form factor and one may hope that it will prove possible to measure them in future. Given the phenomenological importance of the Drell-Yan-West relation (DYWR), it is certainly of considerable theoretical interest to compare the flavour dependence of the large- x PDFs with corresponding large- Q^2 behaviour of the separate flavour contributions to the elastic form factors.

We also investigate the effect of the spectator quark mass on the PDF for a given quark flavor, finding satisfactory agreement with the experimental ratio $\frac{u_{K^+}(x)}{u_{\pi^+}(x)}$. We conclude with a discussion of the relationship of the large- x behaviour of a PDF and the high- Q^2 behaviour of the contribution to the elastic form factor from the same quark.

The comparison of the asymptotic behaviour of the individual flavour form factors and parton distributions is fascinating. While all elastic form factors in the NJL model behave as $\frac{1}{Q^2}$ at larger Q^2 , as already noted, the total K^+ and π^+ form factors only differ by about 10 % in that region. As a reflection of the DYWR, we conclude that this dominance of the elastic form factor for the \bar{s} -quark at large Q^2 is mirrored in the dominance of the strange PDF at large- x , with $\bar{s}_{K^+}(x)/u_{K^+}(x)$ 3 : 1 at large- x .

List of Publications

- **P. T. P. Hutaauruk**, I. C. Cloet and Anthony. W. Thomas *Charge Symmetry Violation Effects in Parton Distributions*, Phys. Lett. **B**-(to be submitted).
- **P. T. P. Hutaauruk**, I. C. Cloet and Anthony. W. Thomas *Flavor Dependence of the Pion and Kaon Elastic Form Factors and Parton Distribution Functions*, Phys. Rev. **C**-(to be submitted).