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## K* nucleon hyperon form factors and nucleon strangeness

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# $K^*$ nucleon hyperon form factors and nucleon strangeness

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## Abstract

A crucial input for recent meson hyperon cloud model estimates of the nucleon matrix element of the strangeness current are the nucleon–hyperon–$K^*$ ($NYK^*$) form factors which regularize some of the arising loops. Prompted by new and forthcoming information on these form factors from hyperon–nucleon potential models, we analyze the dependence of the loop model results for the strange–quark observables on the $NYK^*$ form factors and couplings. We find, in particular, that the now generally favored soft $N\Lambda K^*$ form factors can reduce the magnitude of the $K^*$ contributions in such models by more than an order of magnitude, compared to previous results with hard form factors. We also discuss some general implications of our results for hadronic loop models.

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# I. INTRODUCTION

Understanding the non–valence quark content of hadrons remains, despite a history spanning over two decades, a major theoretical challenge. The interest in non–valence physics derives mainly from the unique opportunities which it provides for new insights into quantum aspects of hadron structure beyond the naive and spectroscopically very successful quark model. Important questions in this realm include modifications of the QCD vacuum inside hadrons [1], the mechanism of flavor mixing and the origin of the OZI–rule [2,3], the structure of constituent quarks [4], and the role of gluons in the dynamics of the (isoscalar) strange–quark sea in the nucleon [5].

The strangeness distribution inside of the nucleon [6] represents the most intensely studied example of a hadronic non–valence quark effect. Currently the vector channel of this distribution, as described by the strange vector form factors, is a focus of experimental [7–9] and theoretical [6,10] research. Since systematic and model–independent approaches have still little predictive power for the nucleon's strangeness content (as exemplified by studies in chiral perturbation theory [11–14] and on the lattice [15]), most previous and current theoretical analyses of the strangeness form factors were model–based.

Among the first and most transparent models for the vector form factors were those which implement a kaon–cloud of the nucleon [16] and thus complement pole dominance approaches [17]. In kaon–cloud models the nucleon's strangeness distribution is generated by fluctuations of the "bare" (i.e. nonstrange) nucleon into kaon–hyperon intermediate states which are described by the corresponding one–loop Feynman graphs [16]. The two crucial assumptions underlying the loop model are 1) that the lightest valence–strangeness carrying intermediate states generate the dominant contribution to the strangeness content and hence give at least a rough estimate of its size, and 2) that rescattering (i.e. multi–loop) contributions are suppressed (despite large couplings).

Both of these assumptions have recently been challenged. A dispersive analysis on the basis of analytically continued $K - N$ scattering data demonstrated that rescattering corrections are important even at low momentum transfers, both to restore unitarity and to build up resonance strength in the $\phi$ meson region [18]. Furthermore, a study in an "un-quenched" quark model found the contributions from higher–lying intermediate states (up to surprisingly large invariant masses) indispensable for the calculation of the strange quark distribution [3] and prompted our collaborators and us to investigate these issues in a complementary hadronic one–loop model [19]. In addition to the original $K - Y$ loops ($Y = \Lambda, \Sigma$), we included the next higher–lying intermediate states, i.e. the $K^* - Y$ pairs. In the first part of this study the corresponding loops were evaluated using Bonn–Jülich $K^*NY$ form factors (see below), as in the original $K - Y$ model. The results were discouraging: the $K^*$ contributions were found to be larger than those from the kaon loop, and their dispersive analysis indicated strong unitarity violations.

The anomalously large and apparently unrealistic $K^*$ contributions could be traced to the large $K^*$ tensor couplings and, in particular, to the very large cutoff parameter of the $K^*N\Lambda$ form factor taken from the Bonn–Jülich potential model [20]. Since both the Nijmegen potential [21,22] and the forthcoming update of the Bonn–Jülich $NY$ potential [23] find substantially smaller values for this cutoff, we feel that a detailed and quantitative analysis of the cutoff (and coupling) dependence of the $K^*$ contributions (covering the whole