Chiral extrapolations of baryon masses

M.F.M. Lutz and A. Semke, GSI, Darmstadt, Germany

We consider the chiral extrapolation of the baryon masses to unphysical quark masses assuming exact isospin symmetry. The dependence on the light quark masses may be traded against a dependence on the pion and kaon masses, where we assume a quark-mass dependence of the meson masses as predicted by χPT at the next-to-leading order with parameters as recalled in [2]. The 'physical' strange quark mass is determined such that at the physical pion mass the empirical kaon mass is reproduced. The baryon masses are computed at N^{3}LO where we use physical baryon and meson masses in the one-loop contributions to the baryon self energies and assume systematically large-N_c sum rules for the parameter set. Our approach is detailed in [1, 2]. Initially we adjusted the parameter set to the physical masses of the baryon octet and decuplet states and to the results for the pion-mass dependence of the nucleon and omega masses as predicted by the BMW group [2]. That initial parameter set was further slightly adjusted in [3] to achieve consistency with recent lattice results of the LHPC and PACS-CS groups. Insisting on a simultaneous description of the BMW and PACS-CS data we unambiguously recover the unfitted results of the HSC and QCDSF-UKQCD groups with an amazing accuracy [4]. We also explored the role of the axial coupling constants F and D, which we found to be accurately determined from a simultaneous fit of the lattice data [4]. In Fig. 1 we show the baryon masses for our favored parameter set as a function of the linear pion mass [3]. It is a striking phenomena that for pion masses larger than 300 MeV there appears to be an approximate linear dependence for all baryon masses. Note however, that given our approach the linear dependence is significantly and systematically altered at smaller pion masses. Our results are confronted against the lattice data from the HSC groups (open circles), which provide data for an almost physical strange quark mass. In order to provide a quantitative comparison, we compute the baryon masses for the pion and kaon masses as predicted by the HSC group. The grey filled circles show our results. The distance of the filled circles to the solid lines measures the importance of taking the precise physical strange quark mass in the computation of the baryon masses. In Fig. 1 we also confront our approach with the simulation data of the PACS-CS (open squares) and QCDSF-UKQCD (open diamonds) groups. Since the later groups use strange quark masses that are significantly off the physical value, the data points are typically quite distant from the solid line. Again our results, green squares and red diamonds, are quite close to their corresponding lattice points, open squares and diamonds. Note that all lattice points are shown with statistical errors only, where we assume the central values of the lattice spacing as provided by the various lattice groups.

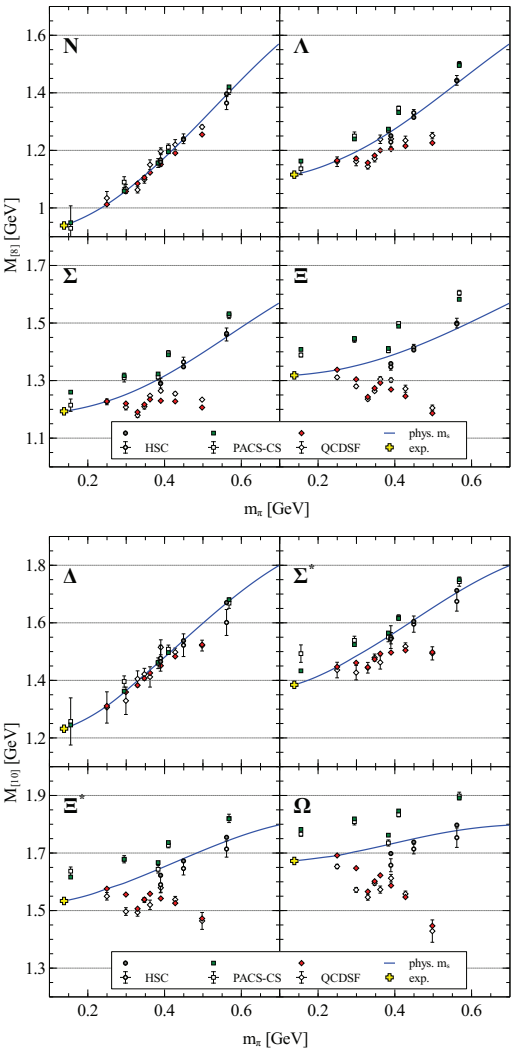

Figure 1: Baryon masses as a function of the pion mass as explained in the text.

References

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