Discussion of baryon systematics

Scale setting using a baryon mass: strongly stable baryons in the light/strange sector

Octet ($J^P = \frac{1}{2}^+$), N, Λ, Σ, Ξ. Decuplet ($J^P = \frac{3}{2}^+$), Ω.

Advantage: more straightforward to compute than decay constants for some actions.

Isospin-breaking effects $\rightarrow$ tomorrow: QED effects $O(1-2)$ MeV. Strong-isospin breaking have been computed or in some cases estimated using (clean, very precise) expt..

Disadvantage: extraction of lattice masses difficult due to signal to noise problem and excited state contamination.

Disadvantage: quark mass dependence difficult to model as convergence properties of SU(2)/SU(3) baryon ChPT not clear $\rightarrow$ Friday.

Additional systematics: finite volume, lattice spacing effects, ...

★ Omega baryon (sss)

- Relatively cheap to compute.
- Signal to noise is better than for most of the octet baryons.
- Along the $m_s = const.$ trajectory, M_Ω has little dependence on the light quark mass.
- Strong-isospin effects only in the sea. (QED effects also needed).
- Finite volume effects are expected to be small.

★ Ξ baryon ($ss\ell$)

- Similar signal to noise compared to the Ω: at the physical point,

$$e^{-(M_\Xi - \frac{1}{2}[2M_{\eta_{ss}} + M_\pi])t} \sim e^{-2.8t/\text{fm}} = \left(\frac{1}{17}\right)^{t/\text{fm}} \quad \text{cf.} \quad e^{-(M_\Omega - \frac{3}{2}M_{\eta_{ss}})t} \sim e^{-3.2t/\text{fm}} = \left(\frac{1}{25}\right)^{t/\text{fm}}$$

- Can be fitted together with other octet baryons $\rightarrow$ large data set with relatively few parameters.

Currently, most groups use M_Ω, but M_Ξ also used.

Challenges:

- ★ Signal to noise.
- ★ Reduction of excited state contamination.
- ★ Fitting to extract the mass.
- ★ Finite volume, chiral-continuum extrapolation, quark mass mis-tuning,...
- ★ Non-unitary setup: matching different actions.

How to tackle these challenges? In the future?

Signal to noise $\rightarrow$ large number of measurements.

- Cost mitigated by e.g. using the truncated solver method.
- Cost of e.g. Gaussian smearing can be significant as the lattice spacing decreases.
- Wall source (point sink) $\rightarrow$ volume average at the source.

New methods? Multi-level methods?

Reduction of excited state contamination $\rightarrow$ GEVP

- Basis of operators, e.g., smeared and point, . . .
- Lower cost: pencil of functions/prony method.
- Lanczos approach equivalent to prony method.

Fitting

- Multi-exponential fits with or without priors.
- Multi-exponential fits to estimate plateau region $\rightarrow$ single exponential.
- Use of model averaging.