Baryon spectrum

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ETM Collaboration

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Outline

- Twisted fermions
- Lattice setup
- Octet of $J = \frac{1}{2}^+$ Baryon
- Chiral extrapolation
- Isospin breaking effects
- Ω baryon

Simulations

- fermions: $N_f = 2$ maximally twisted mass QCD

  $\longrightarrow$ fermionic action composed of a quark doublet.

  $\longrightarrow$ formally equivalent to QCD in the continuum limit and infinite volume limit

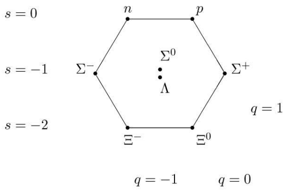
  $\longrightarrow$ automatic O(a) improvement

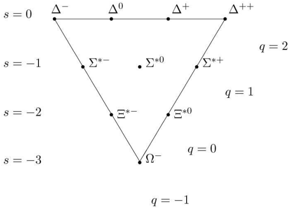
  $\longrightarrow$ But: explicit breaking of parity and isospin in the action

Lattice setup

- three lattice spacings: 0.066 – 0.10 fm
- $270 \lesssim m_{\mathrm{PS}} \lesssim 600$ MeV
- $L > 2$ fm
- $m_\pi L > 3.2$

Decuplet and Octet

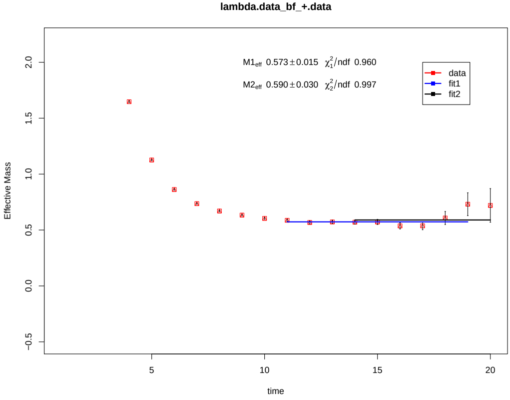




- Partially quenched study : Osterwalder-Seiler strange quark.
- Bare strange quark mass fixed for each value of the lattice spacing in the sector of mesons by V. Lubicz *et al*
- Lattice spacing fixed using f_π
  $\longrightarrow$ no parameter fixed in the baryonic sector
- Mass obtain by computing a 2-points function : i.e $\langle J(x)J(0)\rangle$
- Optimization of the interpolating field with smearing : Gaussian + APE
- Error estimated using Jackknife

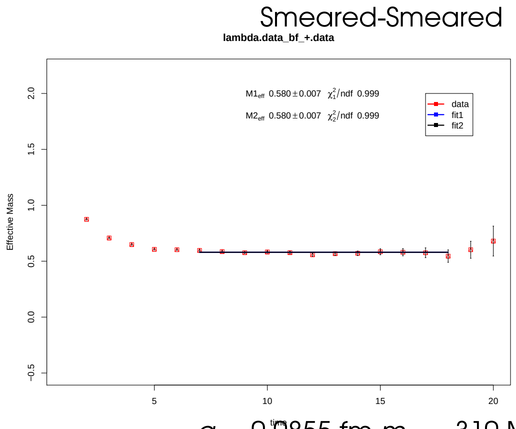
Extraction of masses

Local-Local



$a \sim 0.0855$ fm $m_\pi \sim 310$ MeV

Extraction of masses



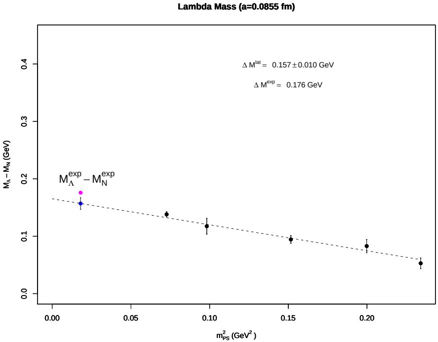
$a \sim 0.0855$ fm $m_\pi \sim 310$ MeV

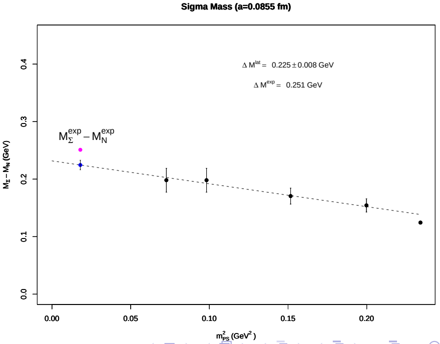
Chiral extrapolation

- Assuming no finite volume and lattice discretization effects
- Polynomial fit of the form :

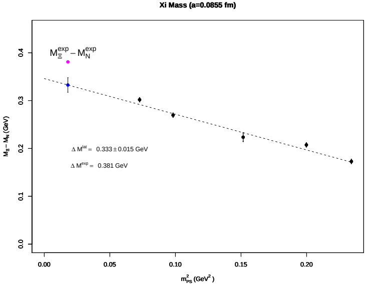
$$M_X = M_0 + aM_\pi^2 + bM_\pi^3$$

- Nucleon case : $HB\chi pT \longrightarrow b_N = -\frac{3g_A^2}{32\pi f_\pi^2}$
- Direct extraction e of the mass difference between the members of the octet and the nucleon





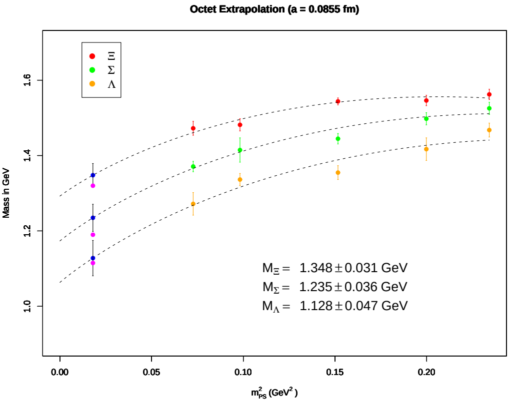
Chiral extrapolation



- Linear behaviour : $b_{octet} \sim b_N$
  $\longrightarrow$ contradiction with $SU(3)$ prediction
- Scale fixed in the pion sector

Chiral extrapolation

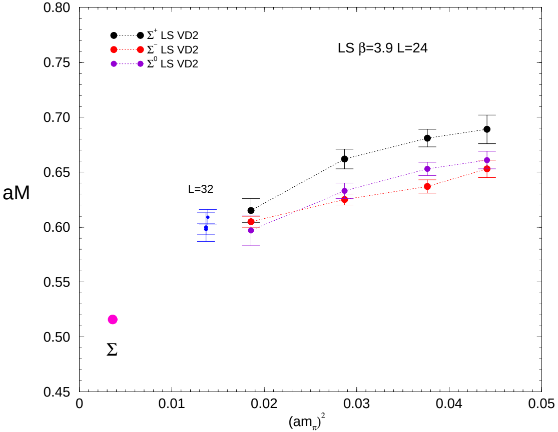
- Extrapolation using the cubic term of the nucleon



$\longrightarrow$ Prediction depends of the value of cubic term

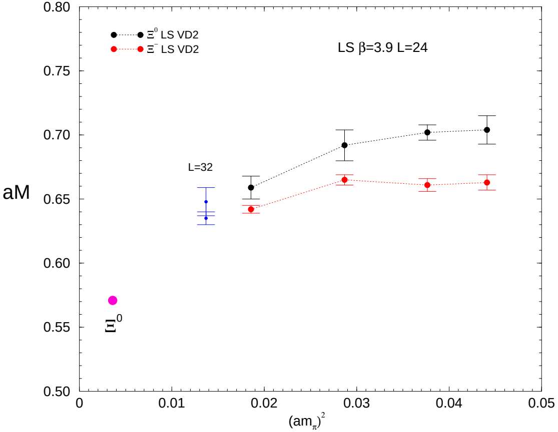
Isospin Breaking

- Test of isospin breaking in the Σ and Ξ sector
- For small pion mass and small lattice spacing all the Σ have to be degenerate



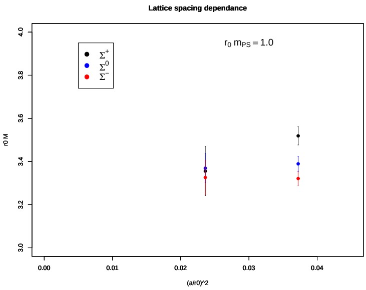
Isospin Breaking

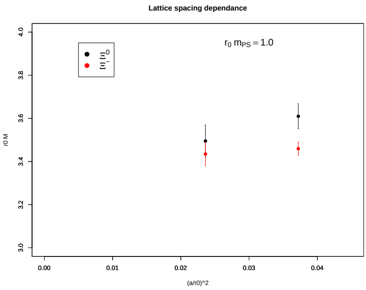
- Idem for the Ξ



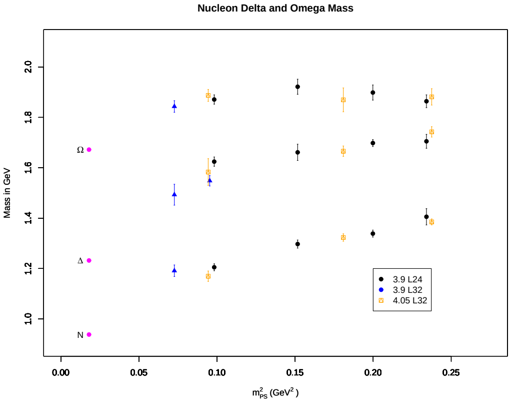
Isospin Breaking

- First attempt to show the decrease of isospin breaking effect for small lattice spacing

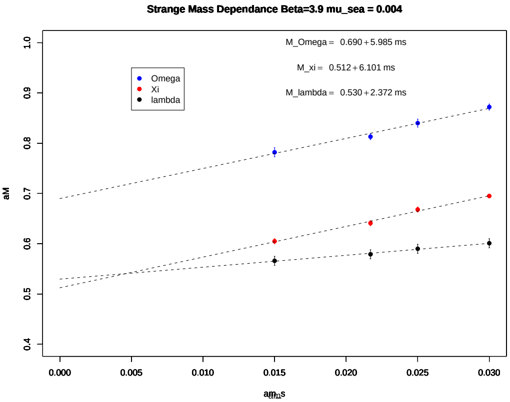




Ω baryon


Nucleon Delta and Omega Mass
Mass in GeV
2.0
1.8
1.6
1.4
1.2
1.0
Ω
Δ
N
0.00
0.05
0.10
0.15
0.20
0.25
m²_PS (GeV²)
3.9 L24
3.9 L32
4.05 L32

Ω baryon


Strange Mass Dependance Beta=3.9 mu_sea = 0.004
M_Omega = 0.690 + 5.985 ms
M_xi = 0.512 + 6.101 ms
M_lambda = 0.530 + 2.372 ms
Omega
Xi
lambda
aM
am_s
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.000
0.005
0.010
0.015
0.020
0.025
0.030

Summary

- Rather important isospin breaking in the octet which vanish when the pion mass is light
- Chiral extrapolation are preleminary due to a cubic term not well known
- m_s dependance is encouraging