Quenched hadron spectroscopy with overlap quarks

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Simulation details

Quenched QCD on a $18^3 \times 64$ lattice, Wilson gauge action, $\beta = 6$, 6-hit Metropolis algorithm (acceptance ≈ 0.5), 100 configurations separated by 10,000 upgrades.

From Wilson loops: $r_0/a = 5.36 \pm 0.11 \;\; (a^{-1} = 2.11 \pm 0.04\mathrm{GeV})$ from the Sommer scale $r_0^2 F(r_0) = 1.65, \; r_0 = 0.5\mathrm{fm}$.

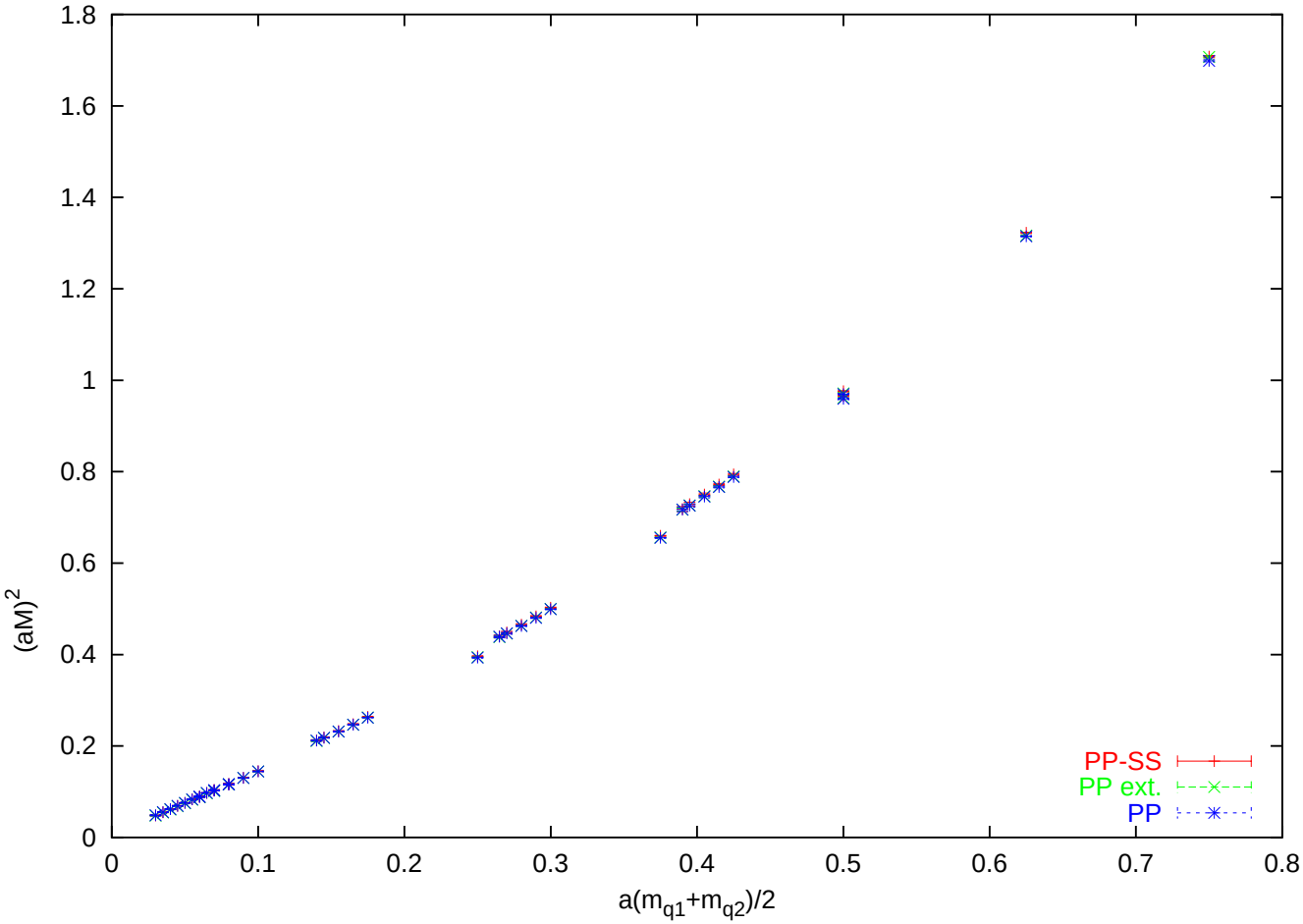
Overlap quark propagators ($\rho = 1.4$) calculated for a single point source, all 12 color-spin combinations and $m_q = 0.03, 0.04, 0.06, 0.08, 0.1, 0.25, 0.5, 0.75$

Zolotarev approx. with 12 poles (used for first 55 configurations), then Chebyshev approx. (degree $100 \sim 500$), after Ritz projection of the lowest 12 eigenvectors of H^2.

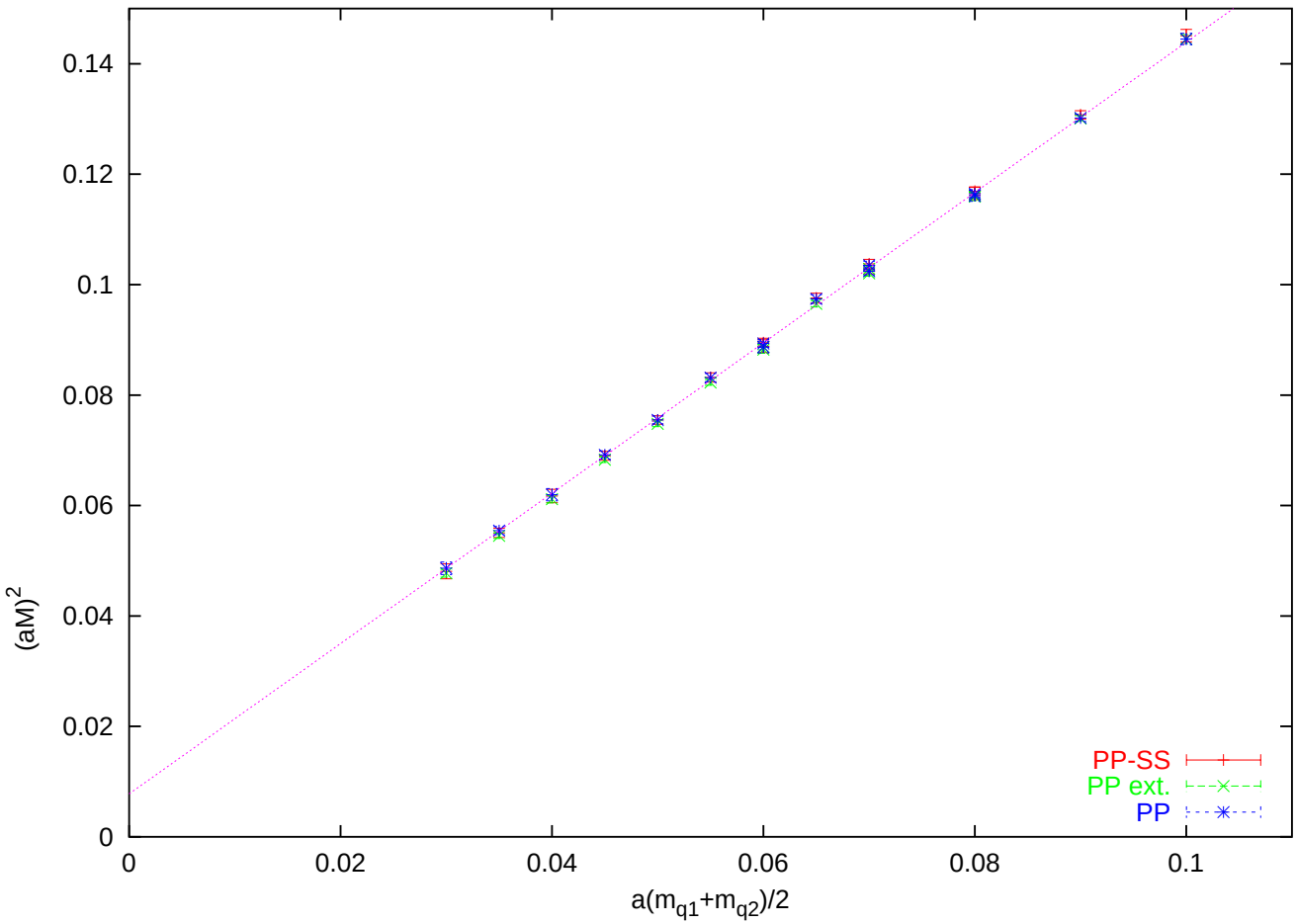
Convergence criterion: $|D^\dagger D\psi - \chi|^2 < 10^{-7}$.

F90 shared memory code, optimized, run on 16 and 32 processor IBM-p690 nodes at BU and NCSA.

Pseudoscalar spectrum

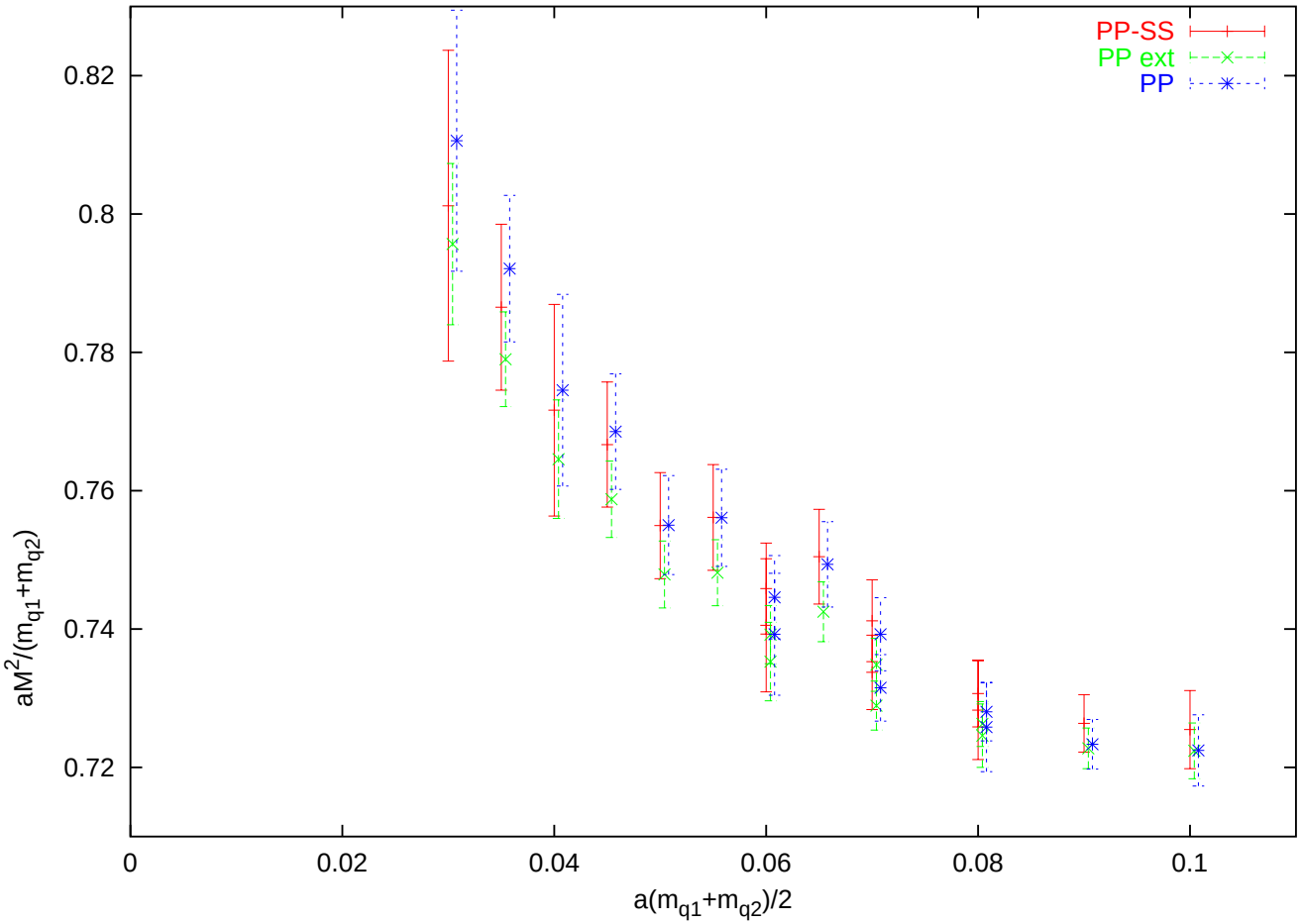


linear for small m



$$(aM)^2 = 1.361(7)(m_{q1} + m_{q2})/2 + 0.0078(5)$$

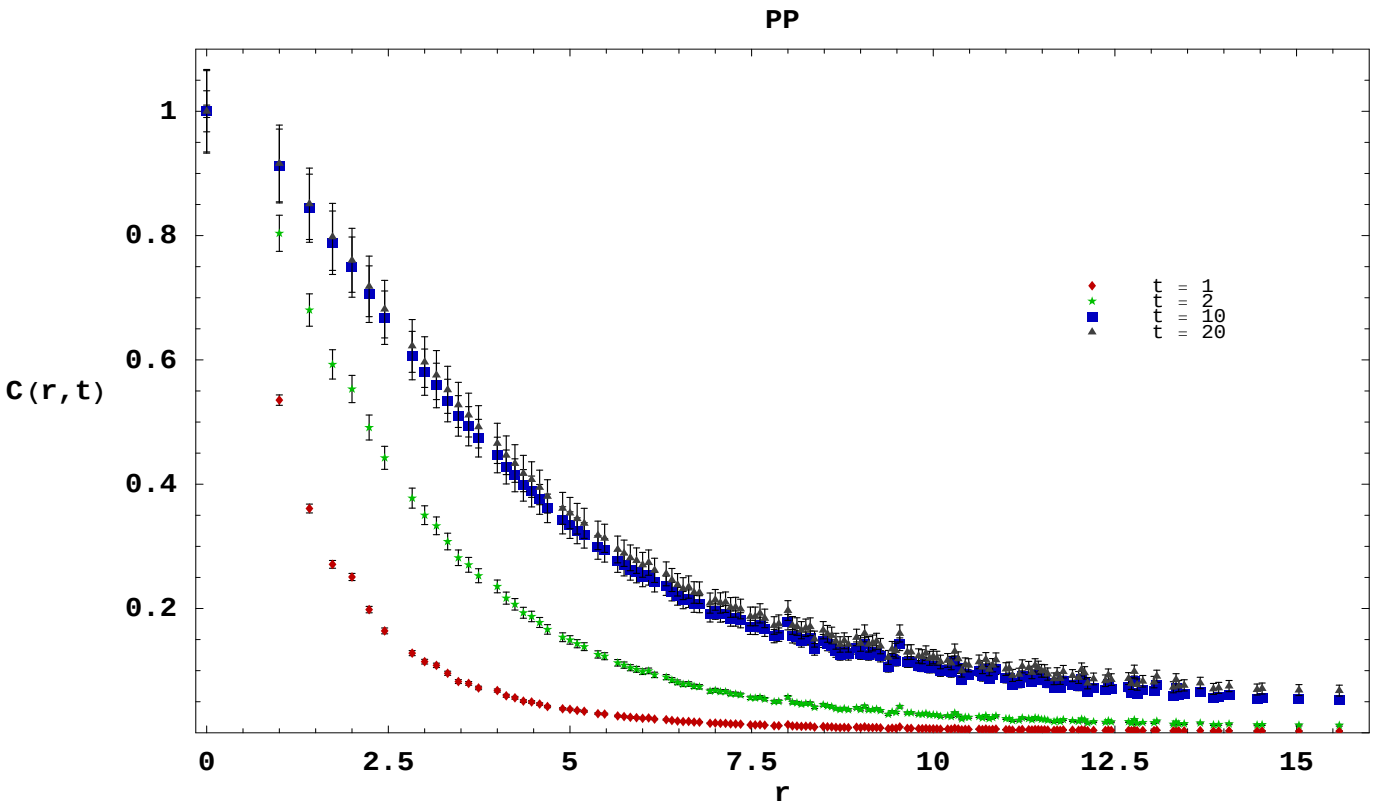
but with deviations from exact chiral behavior



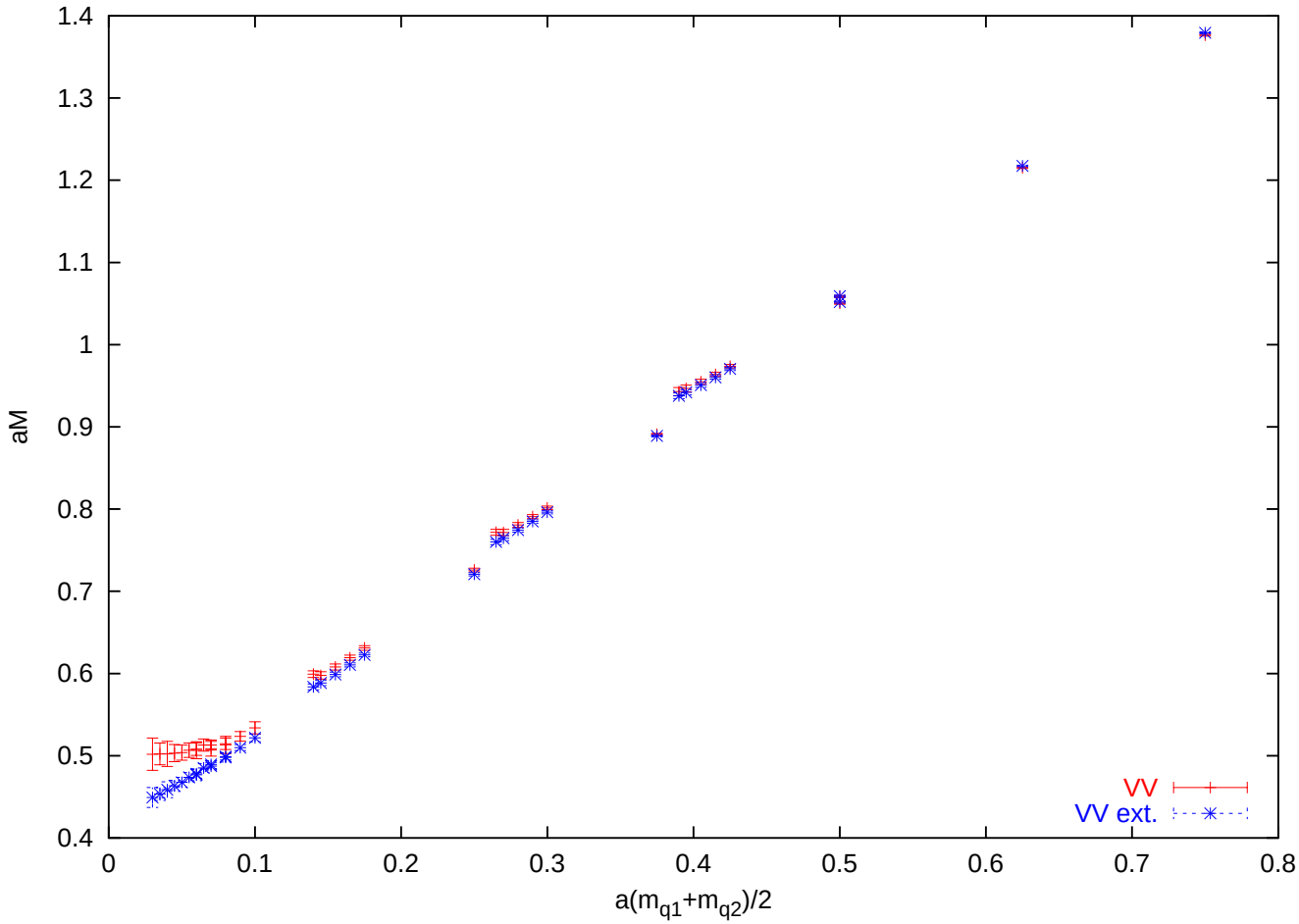
Extended sink operators

$$\langle \sum_{\mathbf{x},\mathbf{y}} \bar{\psi}(\mathbf{x},t)\Gamma\psi(\mathbf{y},t) f(\mathbf{x}-\mathbf{y}) \quad \bar{\psi}(0)\Gamma\psi(0)\rangle$$

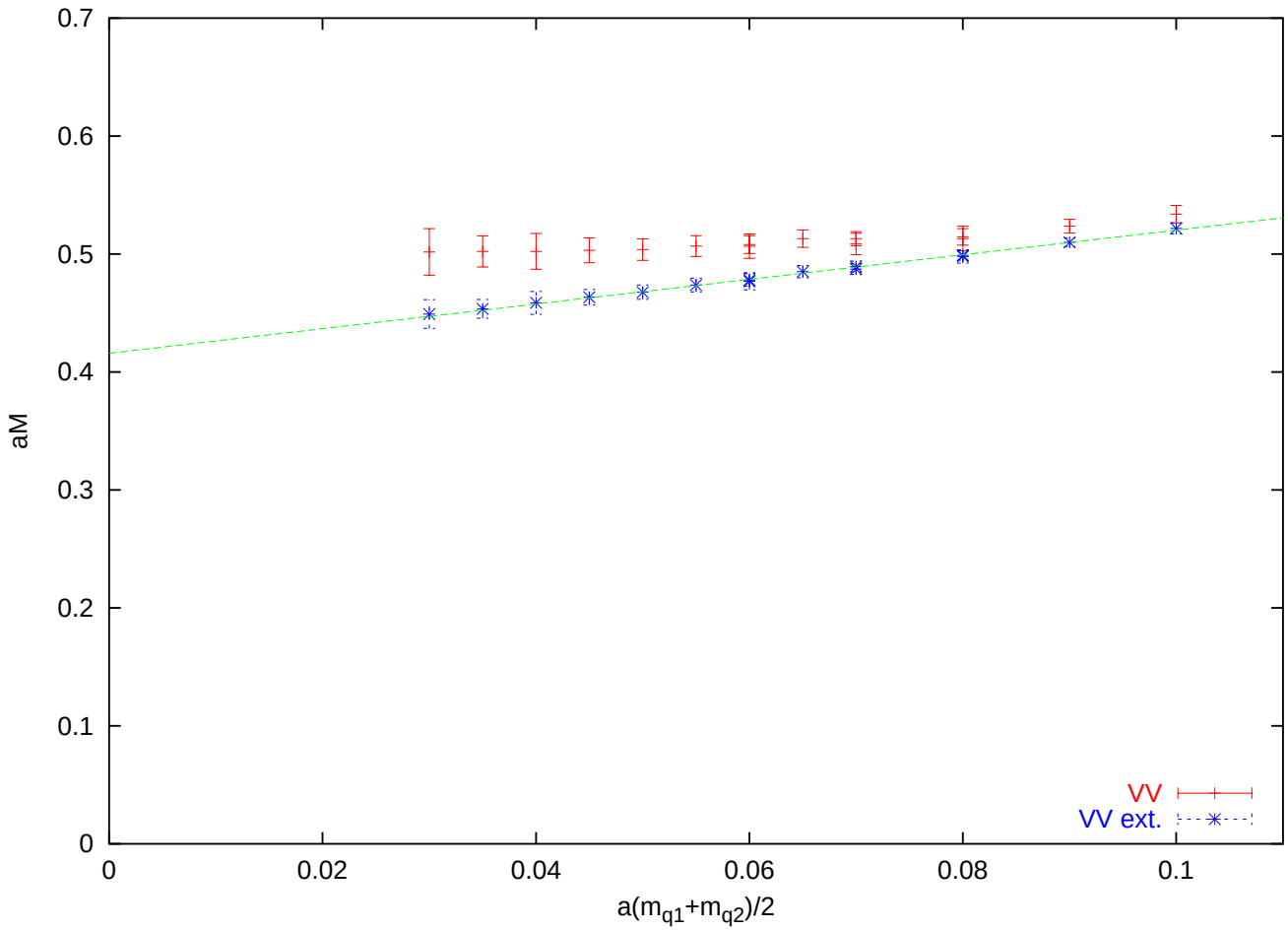
with $\quad f(\mathbf{x}-\mathbf{y}) = \delta(|\mathbf{x}-\mathbf{y}| - r)$:



Vector mesons



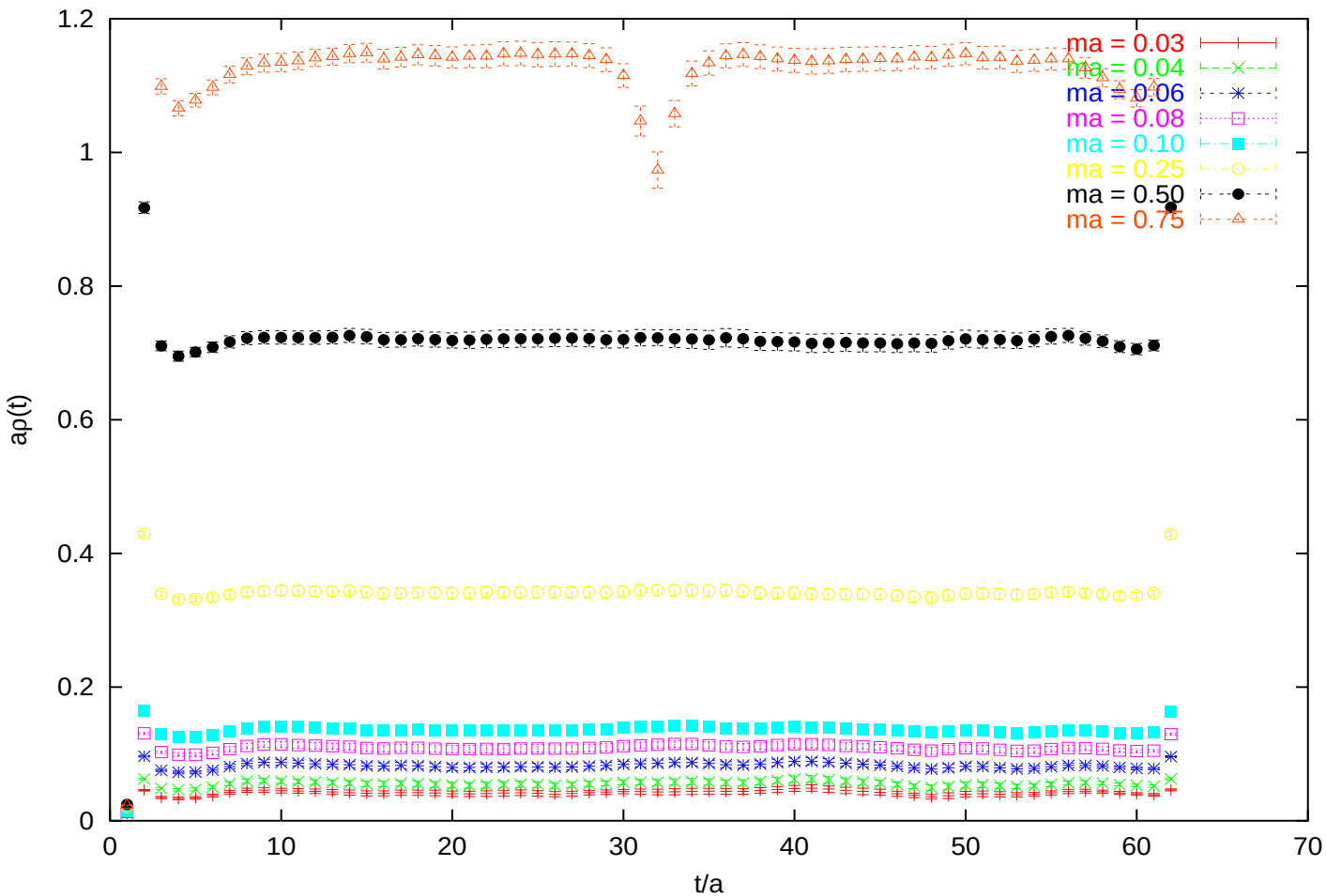
Vector mesons, low m_q



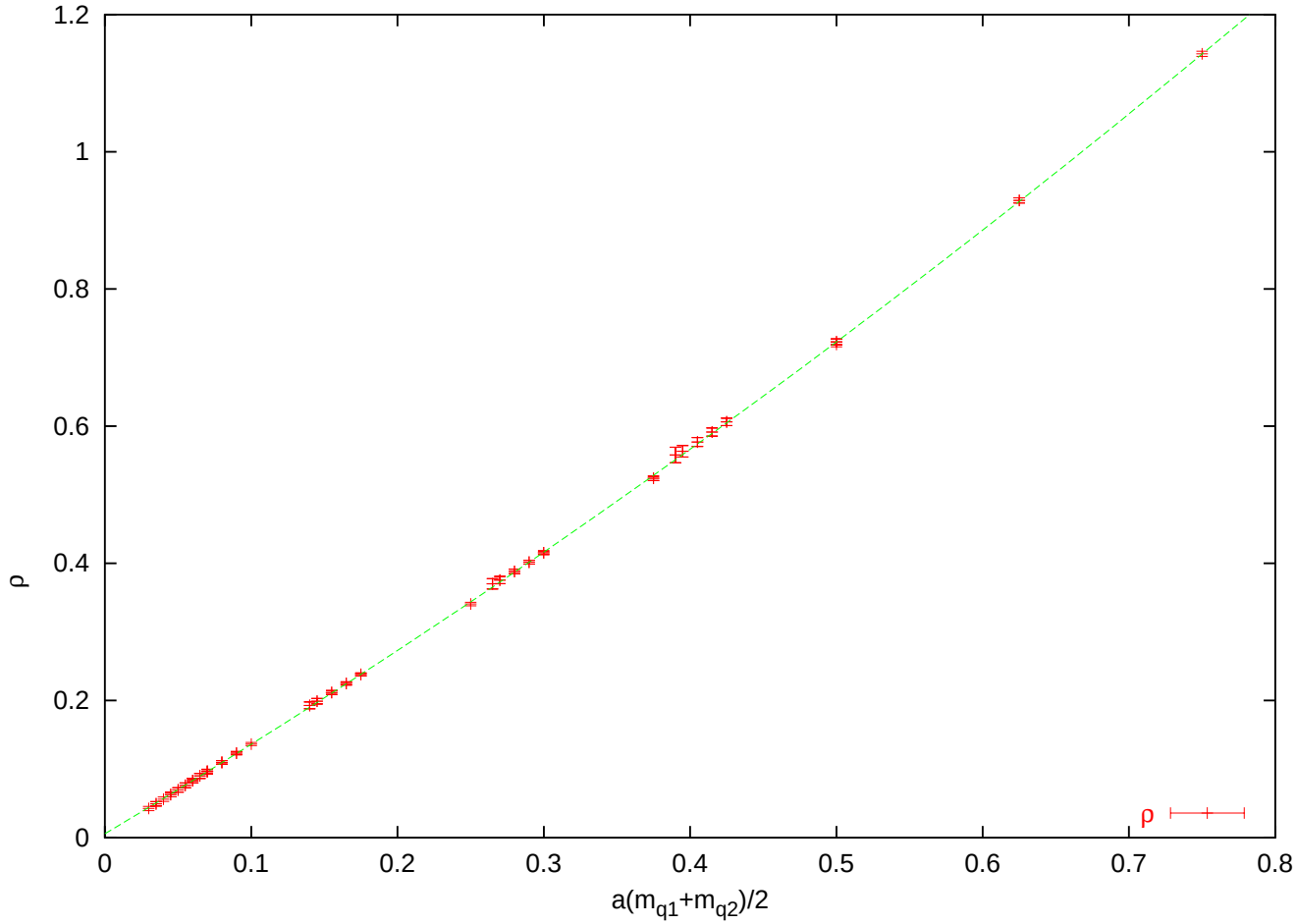
$$aM = 0.4159(11) + 1.044(16)(m_{q1} + m_{q2})/2$$ (extended sink)

Axial Ward identity

$$\rho(t) = G_{\nabla_0 A_0 P}(t)/G_{PP}(t) :$$



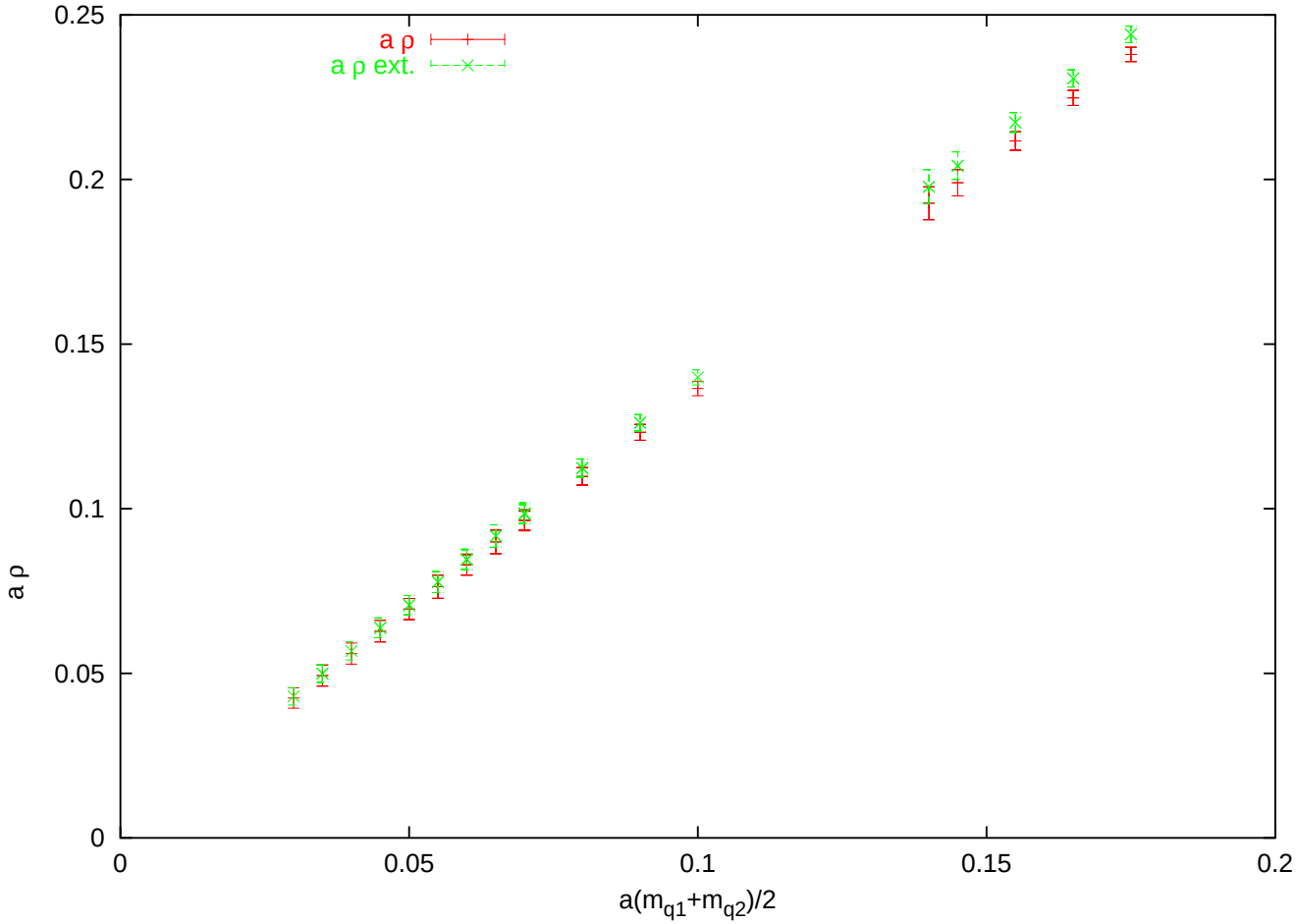
Axial Ward identity, ctd.



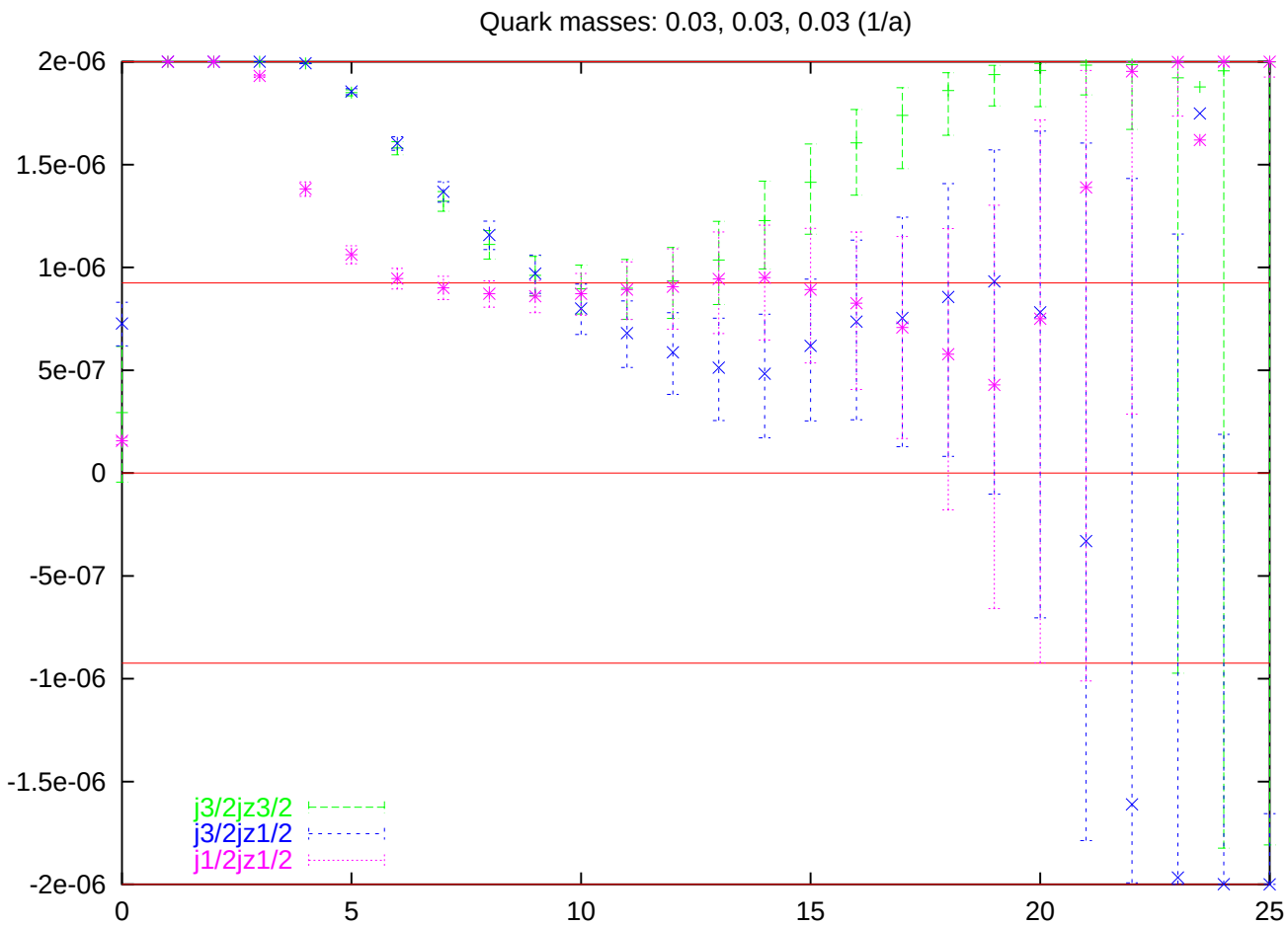
fit to $a\rho = A + Ba(m_{q1} + m_{q2}) + C[a(m_{q1} + m_{q2})]^2$ gives

$A = 0.0057(4), B = 1.271(4), C = 0.326(6), Z_A = 2/B = 1.573(5)$

Axial Ward identity, with extended sink ops.

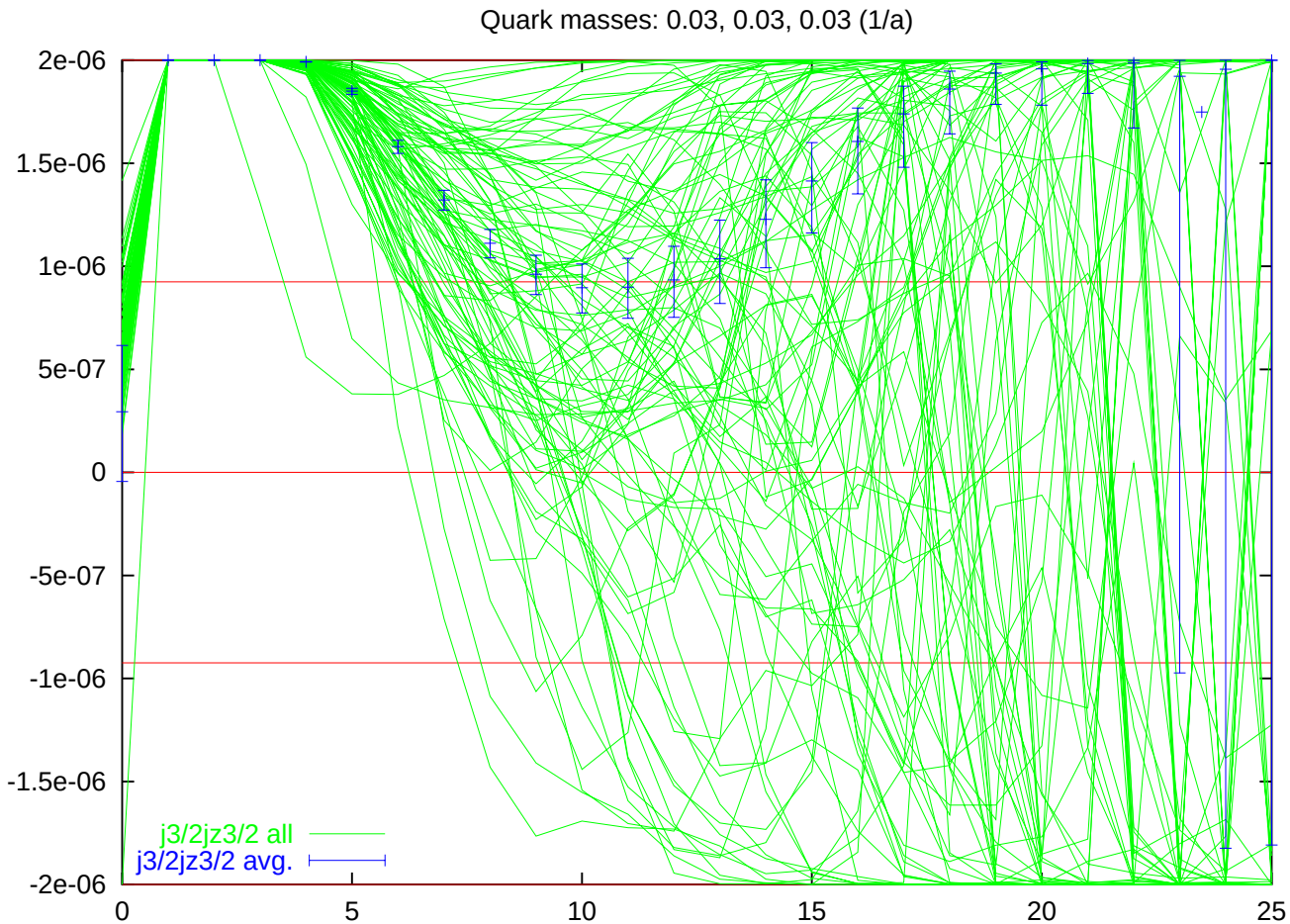


Baryons: caution about fluctuations



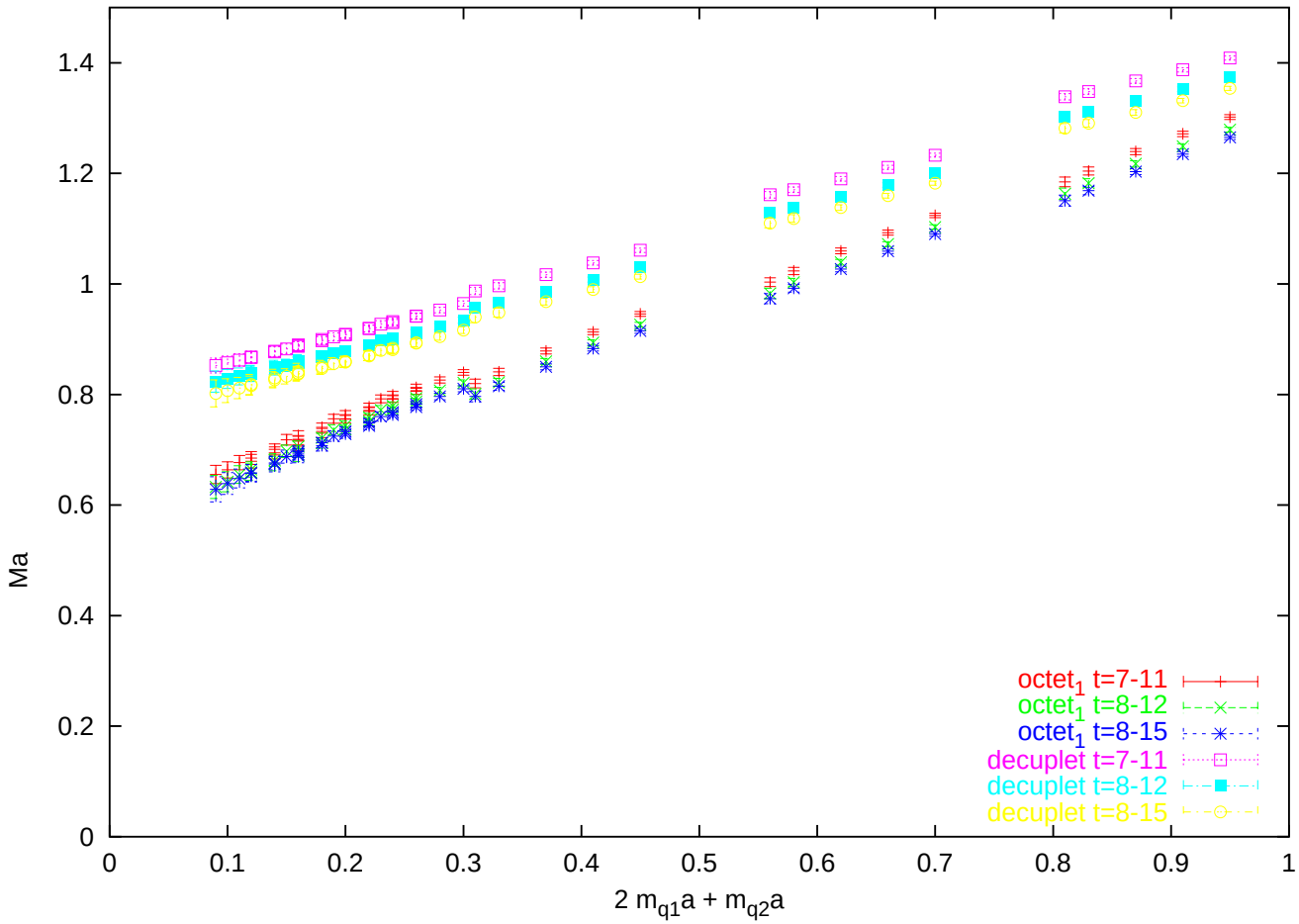
Shown are the average baryon propagators with after multiplication by $\exp(0.65t/a)$ and the mapping $y \to y' = y = 2d\tanh[x/(2d)], \quad d = 10^{-6}$

caution about fluctuations, ctd.

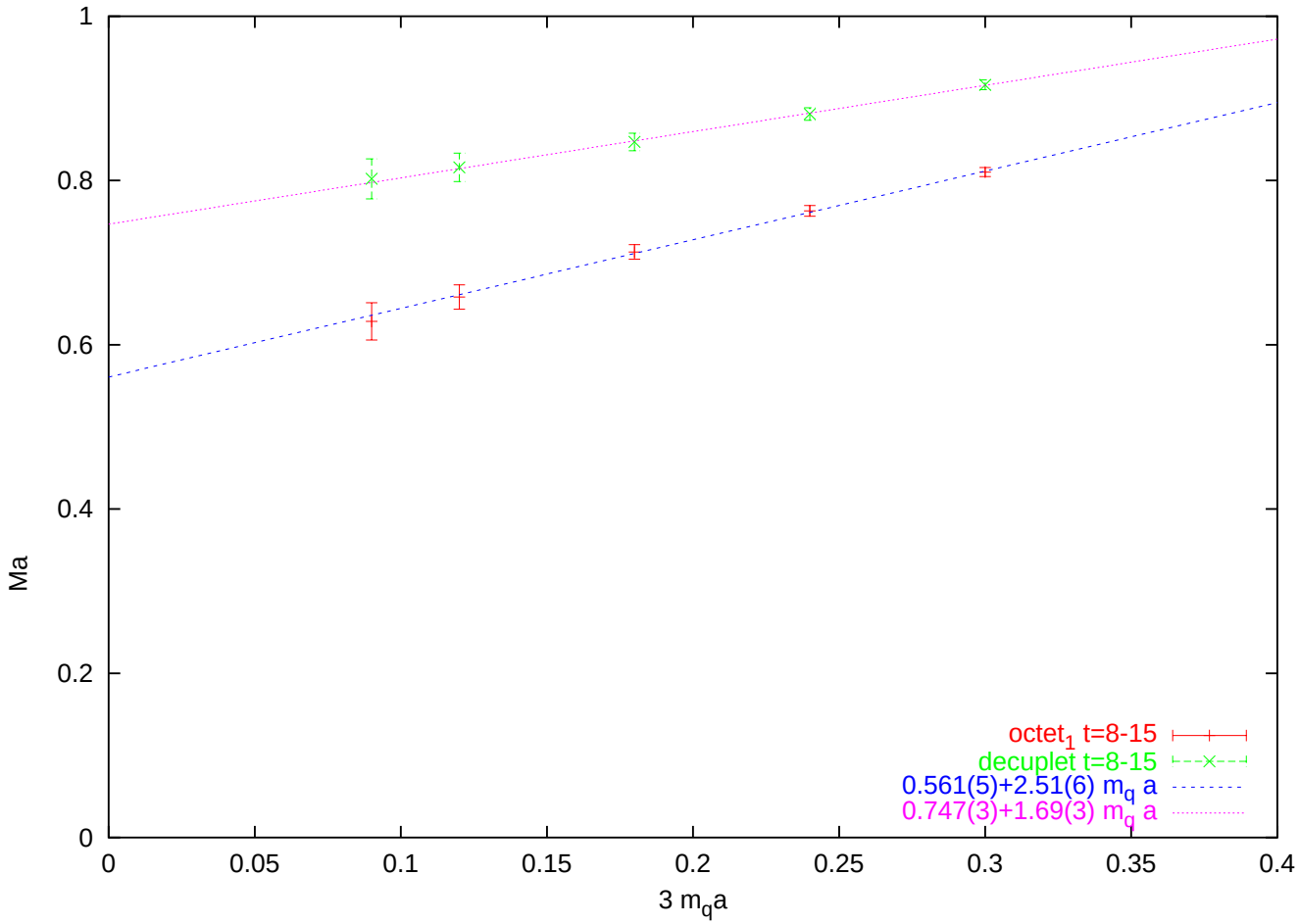


Shown are all decuplet propagators (j_z=3/2) and their average (same transf. as in the previous slide)

Baryons: octet vs. decuplet



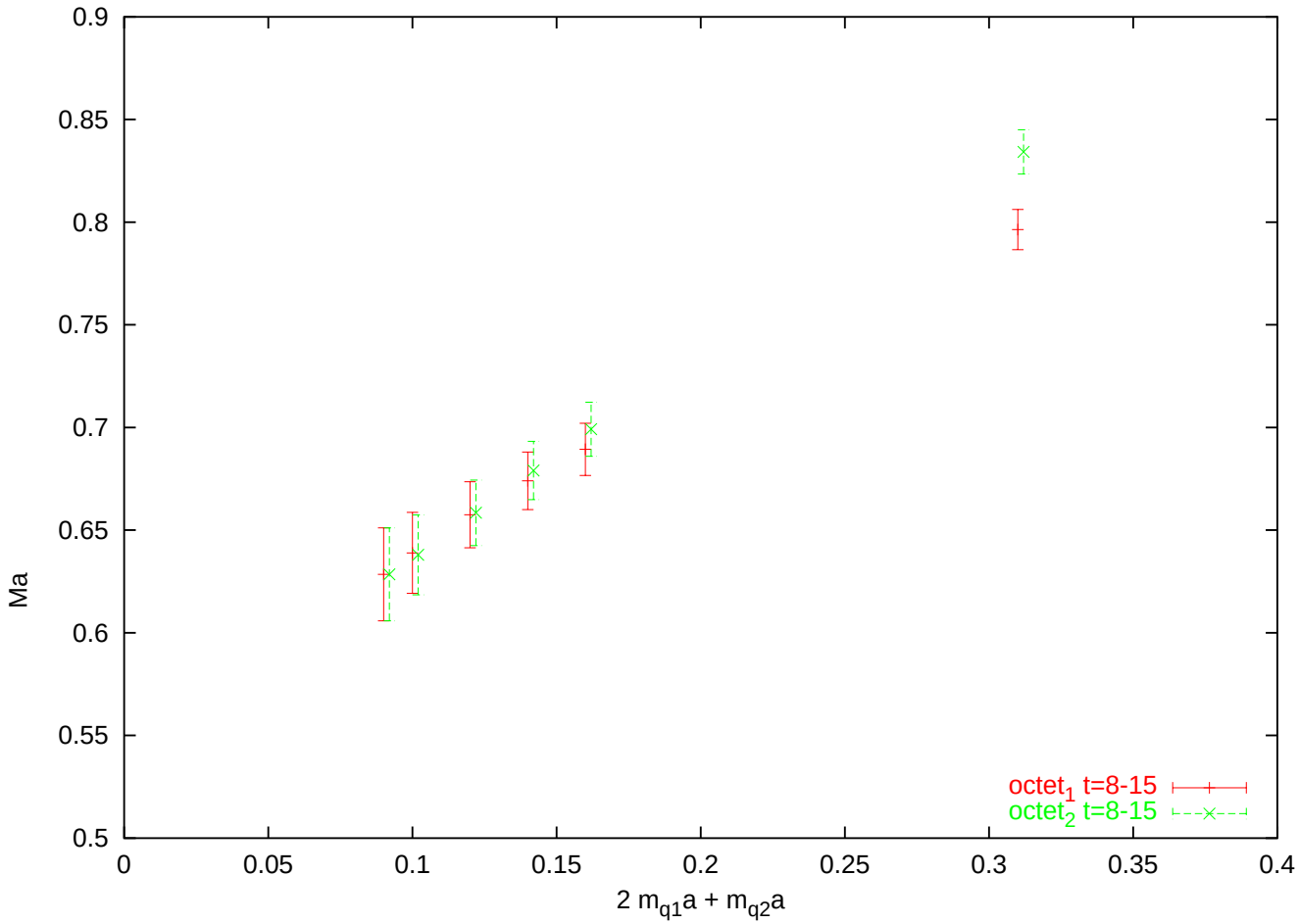
Baryons: low m_{q1}=m_{q2}



Chiral limit: aM_8=0.561(5), aM_{10}=0.747(3), aM_ρ =0.4159(11)

M_ρ/M_8=0.741(9) (exp. 0.820), M_{10}/M_8=1.332(17) (exp. 1.312)

Baryons: octet$_1$ vs. octet$_2$



$$8_1 = (|\uparrow\downarrow\uparrow\rangle - |\downarrow\uparrow\uparrow\rangle)/\sqrt{2} \quad 8_2 = (|\uparrow\downarrow\uparrow\rangle + |\downarrow\uparrow\uparrow\rangle - 2|\uparrow\uparrow\downarrow\rangle)/\sqrt{6}$$

am$_{q1}$ = 0.03, 0.03 $<$am$_{q2}$ $<$ 0.25

In progress:

- Quark correlation functions in the baryon final states
- Quenched calculation on $14^3 \times 48$ lattice at $\beta = 5.85$ to check scaling