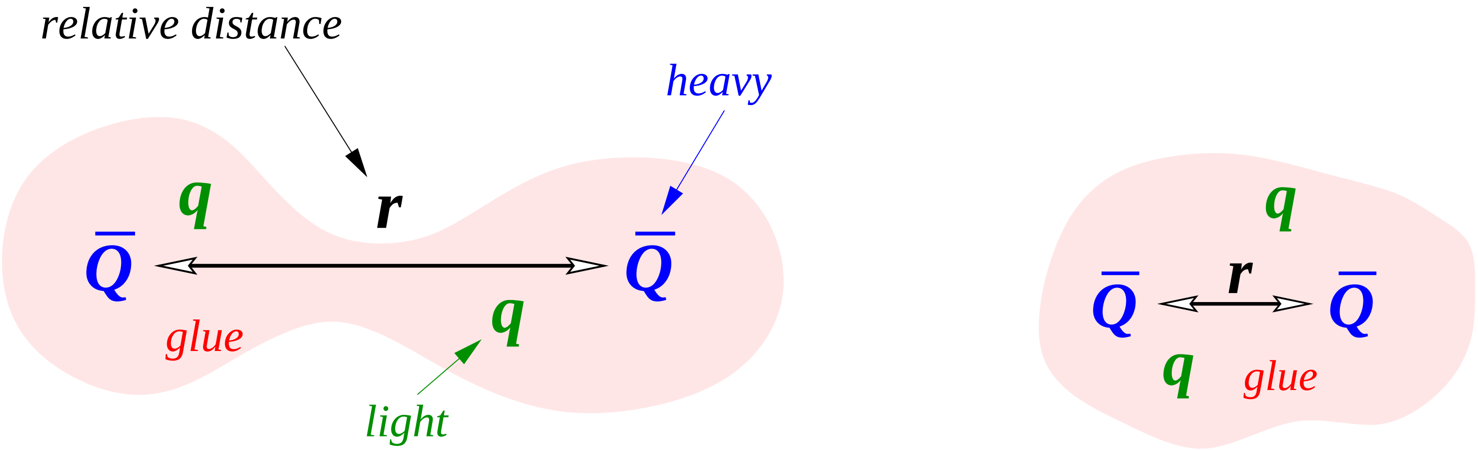
Interaction Mechanism in a Heavy-Light Meson-Meson System[a]

Merritt S Cook and HRF



- static $\overline{Q}$ $\Rightarrow$ well-defined relative distance $\vec{r}$
- importance of gluon vs quark d.o.f. as distance $\vec{r}$ varies

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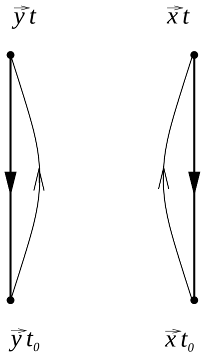
Two-meson operators

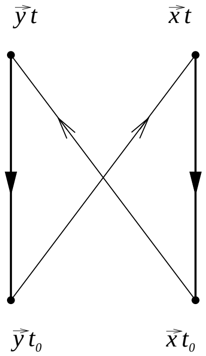
$$
\begin{aligned}
\Phi_1(t) &= \sum_{\vec{x},\vec{y}} \delta_{\vec{r},\vec{x}-\vec{y}} \\
&\quad \overline{Q}_A(\vec{x}t)\gamma_5 q_A(\vec{x}t)\,\overline{Q}_B(\vec{y}t)\gamma_5 q_B(\vec{y}t)
\end{aligned}
$$

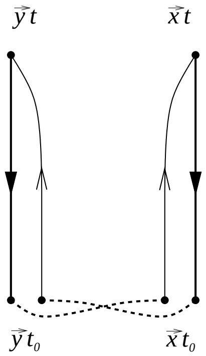
$$
\begin{aligned}
\Phi_2(t) &= \sum_{\vec{x},\vec{y}} \delta_{\vec{r},\vec{x}-\vec{y}}\, U_{P;AA'}(\vec{x}t,\vec{y}t)\, U^{\dagger}_{P';B'B}(\vec{x}t,\vec{y}t) \\
&\quad \overline{Q}_A(\vec{x}t)\gamma_5 q_B(\vec{x}t)\,\overline{Q}_{B'}(\vec{y}t)\gamma_5 q_{A'}(\vec{y}t)
\end{aligned}
$$

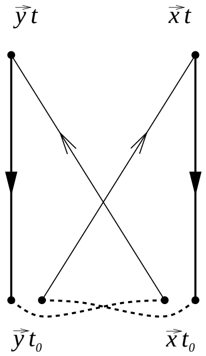
- local vs non-local color singlets
- link products along spatial paths P, P'

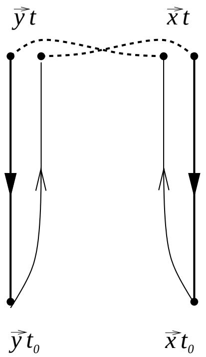
Correlation matrix

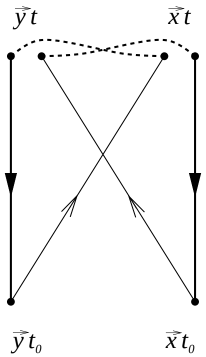
$C_{11} =$ 

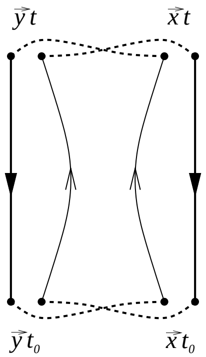
$-$ 

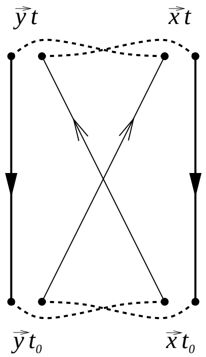
$C_{12} =$ 

$-$ 

$C_{21} =$ 

$-$ 

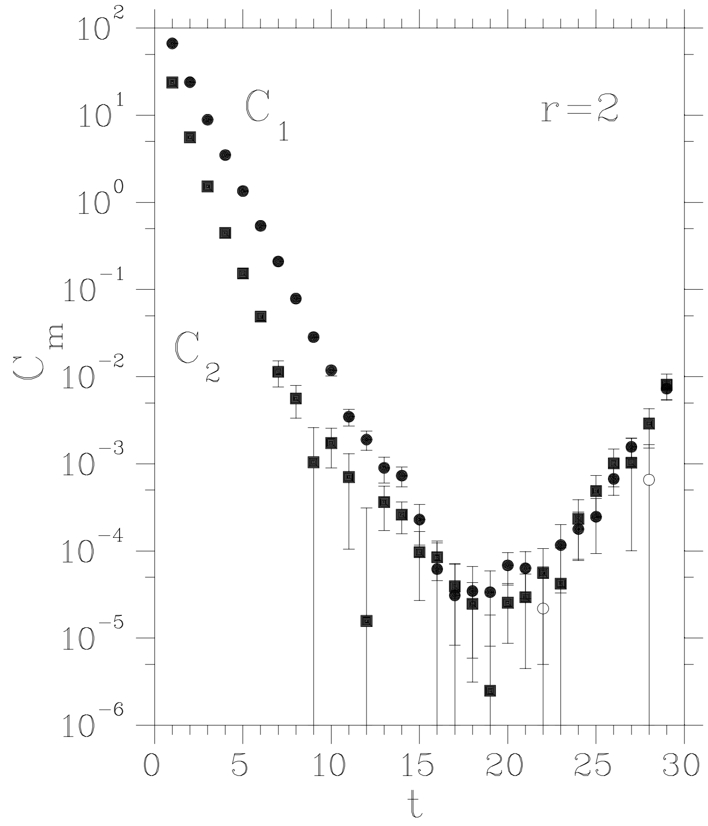
$C_{22} =$ 

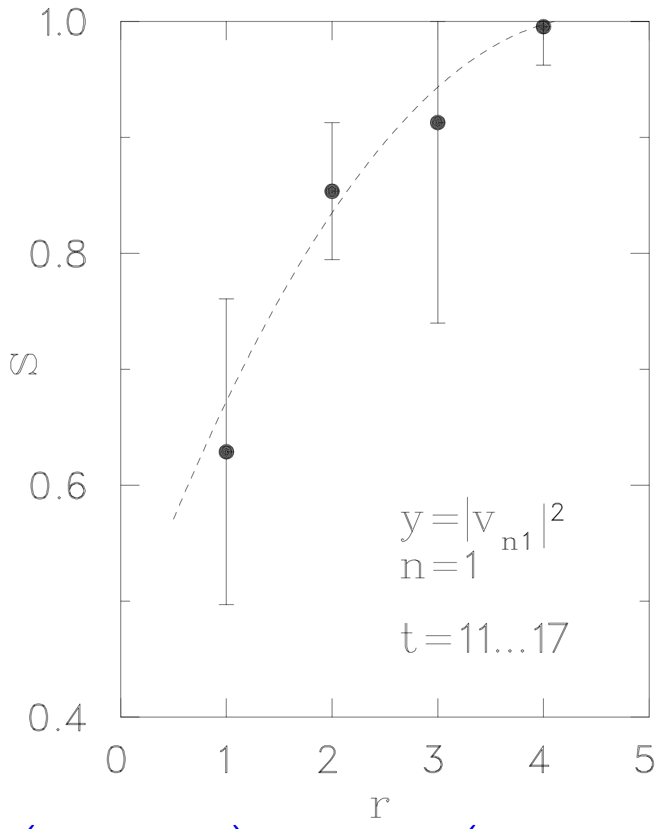
$-$ 

Lattice specs

- Lattice $L^3 \times T = 10^3 \times 30$
- anisotropic $a_s \simeq 3a_t \simeq 0.25$fm (coarse)
- tree-level tadpole improved Glue
- ditto, Wilson+Clover, $m_\pi/m_\rho \simeq 0.75$
- glue, APE fuzzing
- light quark operators, Gaussian smearing
- q-propagator, all–to–all $G(\vec{y}t, \vec{x}t_0)$
  random source estimator $(MG_R = R)$, 8 sources per color-spin
- Lüscher-Wolff type analysis: diag C on each t slice, use $t \to \infty$

$$\begin{pmatrix} C_{11}(t,t_0) & C_{12}(t,t_0) \\ C_{21}(t,t_0) & C_{22}(t,t_0) \end{pmatrix} \begin{pmatrix} v_{m1}(t,t_0) \\ v_{m2}(t,t_0) \end{pmatrix} = C_m(t,t_0) \begin{pmatrix} v_{m1}(t,t_0) \\ v_{m2}(t,t_0) \end{pmatrix}$$





Fit $s = |v_{n1}|^2$ in asymp t range $\Rightarrow$ $\bar{v}_1 = \begin{pmatrix} \sqrt{s} \\ \sqrt{1-s} \end{pmatrix}$ $\bar{v}_2 = \begin{pmatrix} \sqrt{1-s} \\ -\sqrt{s} \end{pmatrix}$

Analysis

$$\hat{C}_m(t,t_0) = \sum_{n\neq 0} |\langle n|\hat{\Psi}_m(t_0)|0\rangle|^2 e^{-\omega_n(t-t_0)} = \int_{-\infty}^{+\infty} d\omega\, \rho(\omega) e^{-\omega(t-t_0)}$$

→ max entropy method (MEM)

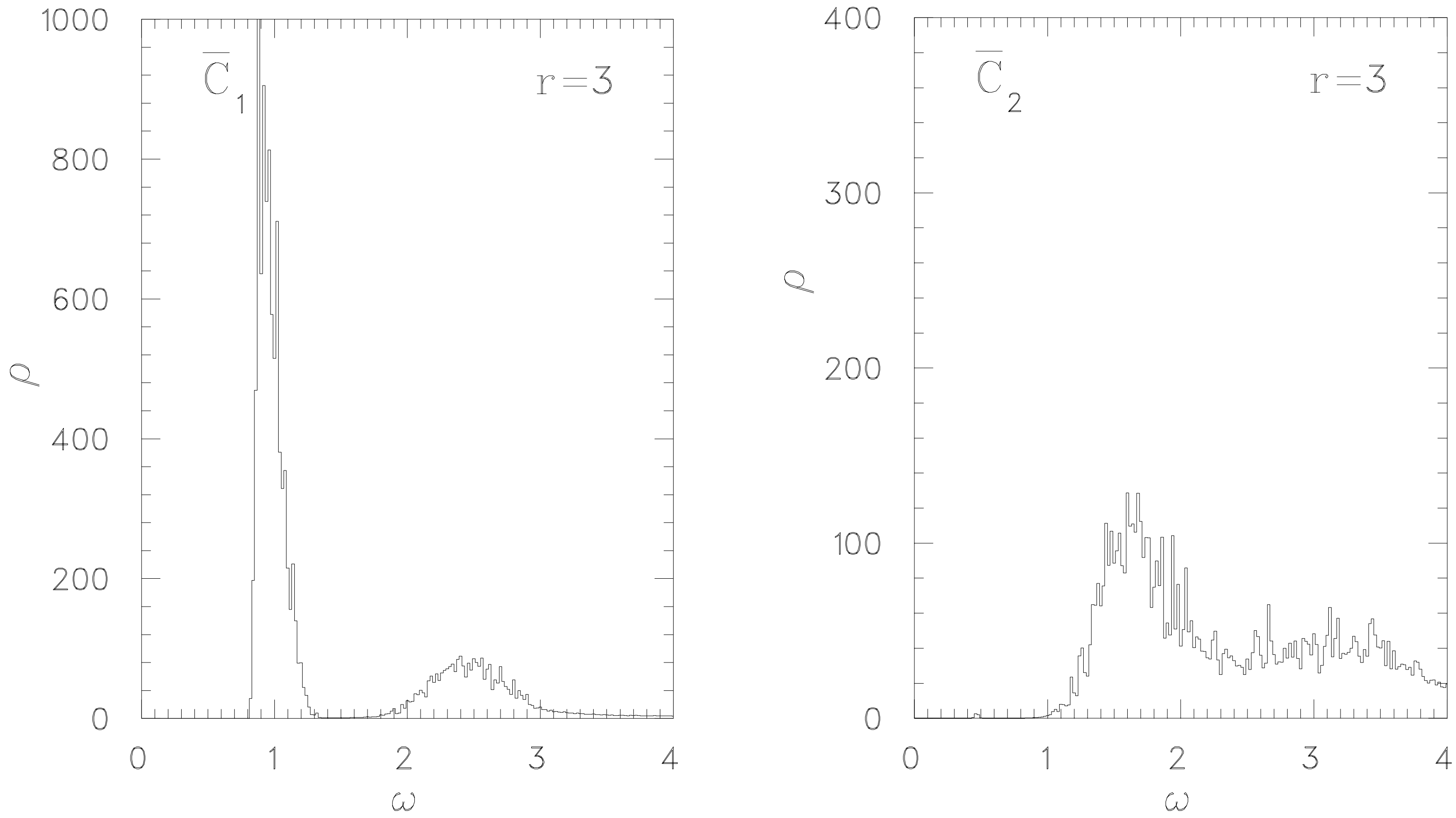
→ simulated annealing (cooling)

→ spectral density $\rho(\omega)$

→ peaks $\delta_n, n = 1, 2 \ldots$

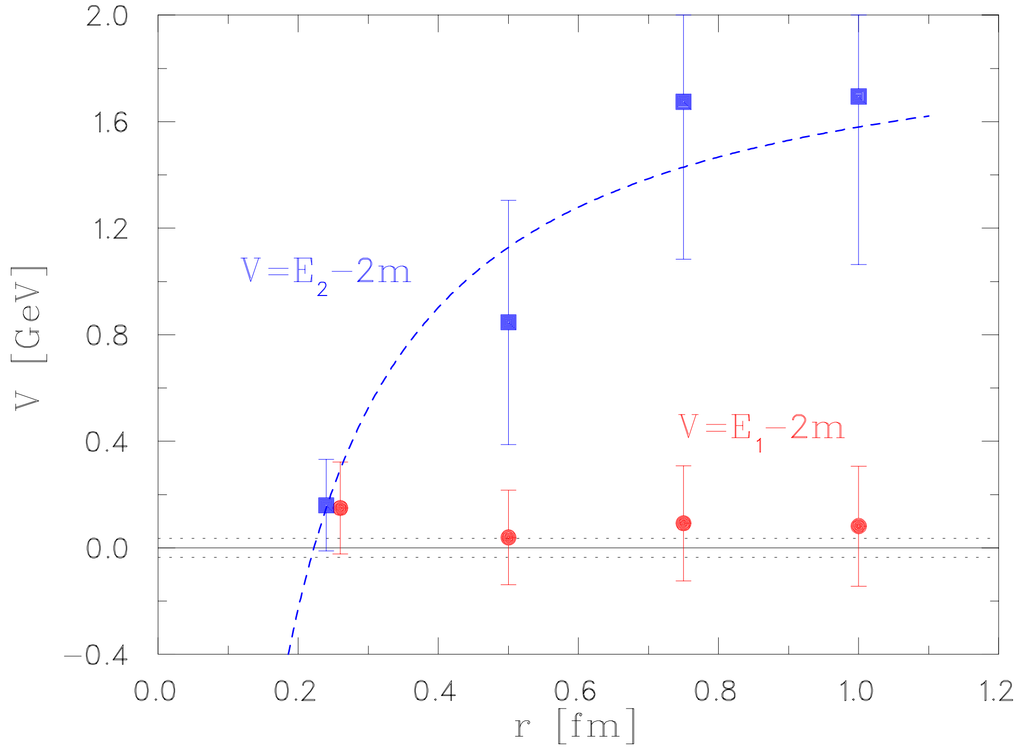
Spectral Observables

$$\begin{array}{llcl} \textit{volume} & Z_n & = & \int_{\delta_n} d\omega \rho(\omega) \quad \cong \quad |\langle n|\hat{\Psi}_m(t_0)|0\rangle|^2 \\ \textit{mass} & E_n & = & Z_n^{-1} \int_{\delta_n} d\omega \rho(\omega)\omega \\ \textit{width} & \Delta_n^2 & = & Z_n^{-1} \int_{\delta_n} d\omega \rho(\omega) \left(\omega - E_n\right)^2 \end{array}$$



1000
800
600
400
200
0
ρ
$\bar{C}_1$
r=3
0
1
2
3
4
ω
400
300
200
100
0
ρ
$\bar{C}_2$
r=3
0
1
2
3
4
ω

Conclusion



- Glimps at physics of interaction

  evidence of mixing quark and gluon d.o.f.

  exchange of $\bar{q}q$ for $r > 0.2\text{fm}$

  gluons take over for $r < 0.2\text{fm}$