Note for g.s. fit

Tony Chu and Jinchen He
Tusng-Dao Lee Institute & Shanghai Jiao Tong University

November 10, 2021

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1 Choice of fit method

1.1 Fit function

In the two states fit method, we did joint fit with three parts: local matrix element $C(z=0,t)$, real and imag part of ratio $\frac{C(z,t)}{C(z=0,t)}$.

1. For local part
$$C(z=0,t) = ce^{-E_0 t}\left(1 + a_1 e^{-\Delta E t}\right)$$

2. For real/imag part of ratio
$$\frac{C(z,t)}{C(z=0,t)} = \frac{\phi_2\left(1 + b_{1(re/im)} e^{-\Delta E t}\right)}{1 + a_1 e^{-\Delta E t}}$$

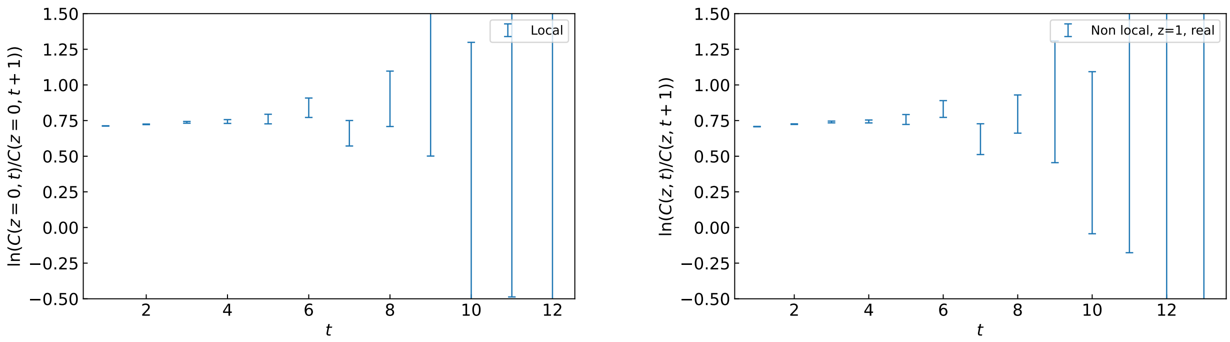
In the one state fit method, we fit real/imag part of ratio directly,
$$\frac{C(z,t)}{C(z=0,t)} = \phi_{2(re/im)}$$

One state fit v.s. two states fit, which shoule we choose in the analysis of two point data? Two figures are helpful before we set about doing fits:

1. Effective mass plot of local matrix element.
$$\ln\left(\frac{C(z=0,t)}{C(z=0,t+1)}\right) = E_0 + \ln(1 + a_1 e^{-\Delta E t}) - \ln(1 + a_1 e^{-\Delta E t - \Delta E})$$
Therefore, if the effective mass plot is horizontal without decay behavior through t-axis, it is impossible to extract excited state contamination successfully.

2. Effective mass plot of non-local matrix element.

1.2 Example 1



(a) Local matrix element

(b) Non-local matrix element

Figure 1: Effective mass

Neither of two plots of effective mass above shows the exponential decay behavior at small t region, so the one state fit method is suggested.

This is the output of two states fit,

$$\begin{aligned}
&\text{Least Square Fit:}\\
&\text{chi2/dof [dof]} \ = 0.91[18] \quad Q = 0.57 \quad \log GBF = 96.901\\
&\text{Parameters:}\\
&g.s._{re} \quad 0.8964(25)\\
&a1 \quad -2.6(6.5)\\
&b1_{re} \quad -1.6(4.1)\\
&dE1 \quad 1.30(73)\\
&E0 \quad 0.7442(82)
\end{aligned} \tag{1}$$

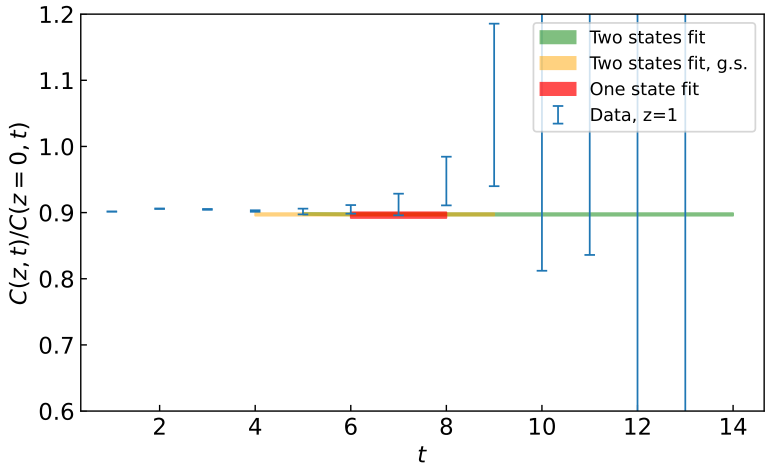
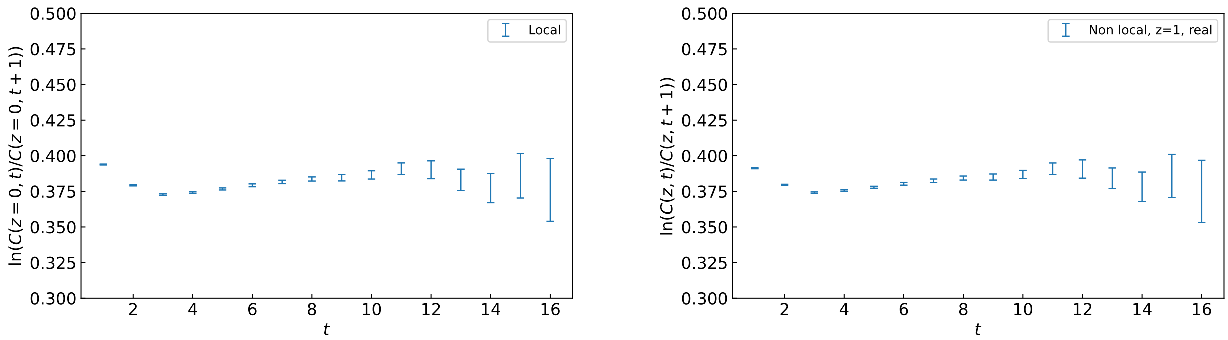


Figure 2: Fit result comparison

From the output it can be found that the fit result of excited state's coefficient b_1 covers zero within the error, which means the two states fit failed to extract the excited state contamination.

1.3 Example 2



(a) Local matrix element

(b) Non-local matrix element

Figure 3: Effective mass

Both of two plots of effective mass above shows the exponential decay behavior at small t region, so the two states fit is worthy to try.

This is the output of two states fit,

$$\begin{array}{l}
\text{Least Square Fit:} \\
\text{chi2/dof [dof]} \;= 0.2[21] \quad Q = 1 \quad \log GBF = 194.25 \\
\text{Parameters:} \\
g.s._{re} \quad 0.95954(56) \\
a1 \quad -0.231(41) \\
b1_{re} \quad -0.206(40) \\
dE1 \quad 0.294(53) \\
E0 \quad 0.3899(20)
\end{array} \tag{2}$$

From the output it can be found that the fit result of excited state's energy ΔE and coefficient b_1 does not cover zero within the error, which means the two states fit succeeded to extract the excited state contamination.

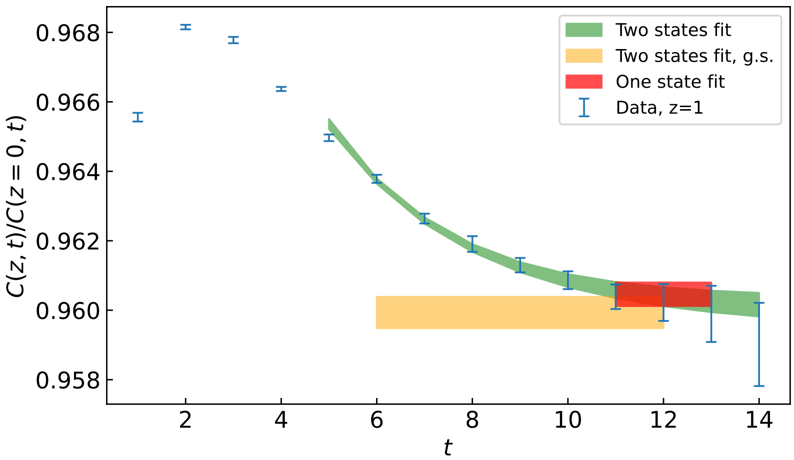


Figure 4: Fit result comparison