课题组组会-练习 6

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一　练习及结果

1. 在 $x \in [0,1]$ 的均匀网格上尝试使用 Variational Reconstruction (VR) 对 $f(x), g(x)$ 分别进行 P0P2，P1P2 重构，其中 $f(x) = 1 + x + x^2, g(x) = sin(\pi x)$.

a) 尝试调整不同阶次的权重系数及边界面权重系数，测试重构精度。

b) 如果网格为不均匀网格呢？

c) 如果考虑 Hyperbolic rDG，进行 DG(P0P2)+rDG(P0P1), 使用 VR 重构算法，结果如何？

a) 解：P0P2

本题均考虑非均匀网格，均匀网格视为非均匀网格的特例。

下面给出 Interfacial jump integration 的定义以及 P0P2 的限制方程组。

$$I = \sum_{f=1}^{N_f} I_f, I_f = \frac{1}{d_{LR}} \left(\omega_0^2 [u]^2 + \omega_1^2 [u_x]^2 d_{LR}^2 + \omega_2^2 [u_{xx}]^2 d_{LR}^4 \right), [u] = u_L - u_R$$

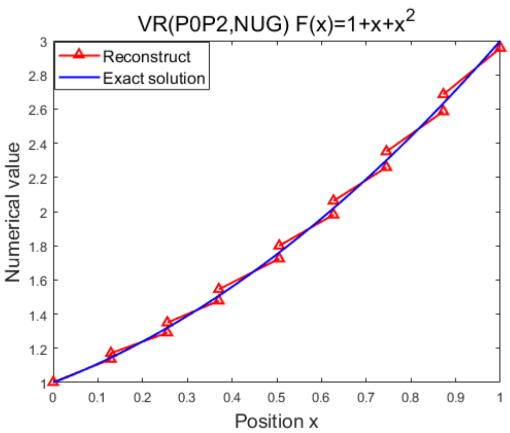
限制方程组:

$$\begin{cases} \dfrac{\partial I_f}{\partial u_{2L}} = 0 \\ \dfrac{\partial I_f}{\partial u_{3L}} = 0 \\ \dfrac{\partial I_f}{\partial u_{2R}} = 0 \\ \dfrac{\partial I_f}{\partial u_{3R}} = 0 \end{cases}$$

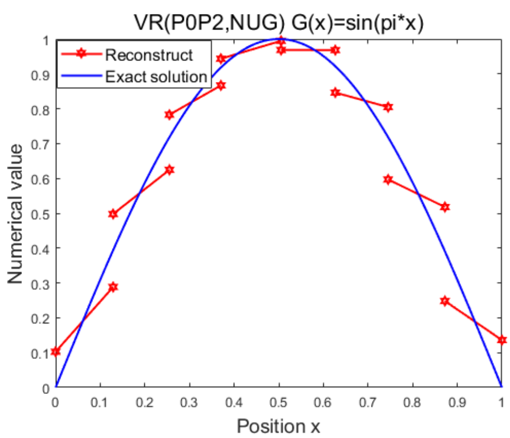
即

$$
\left\{
\begin{aligned}
&\frac{2}{d_{LR}}\left(\omega_0^2\left(\sum_{i=1}^{3}u_{iL}B_{iL}-\sum_{i=1}^{3}u_{iR}B_{iR}\right)B_{2L}+\omega_1^2\left(\frac{1}{\Delta x_{ieL}}\sum_{i=2}^{3}u_{iL}B_{i-1L}-\frac{1}{\Delta x_{ieR}}\sum_{i=2}^{3}u_{iR}B_{i-1R}\right)\frac{1}{\Delta x_{ieL}}d_{LR}^2\right)=0\\
&\frac{2}{d_{LR}}\left(\omega_0^2\left(\sum_{i=1}^{3}u_{iL}B_{iL}-\sum_{i=1}^{3}u_{iR}B_{iR}\right)B_{3L}+\omega_1^2\left(\frac{1}{\Delta x_{ieL}}\sum_{i=2}^{3}u_{iL}B_{i-1L}-\frac{1}{\Delta x_{ieR}}\sum_{i=2}^{3}u_{iR}B_{i-1R}\right)B_{2L}\frac{1}{\Delta x_{ieL}}d_{LR}^2+\right.\\
&\left.\omega_2^2\left(\Delta x_{ieL}^{-2}u_{3L}-\Delta x_{ieR}^{-2}u_{3R}\right)\Delta x_{ieL}^{-2}d_{LR}^4\right)=0\\
&\frac{-2}{d_{LR}}\left(\omega_0^2\left(\sum_{i=1}^{3}u_{iL}B_{iL}-\sum_{i=1}^{3}u_{iR}B_{iR}\right)B_{2R}+\omega_1^2\left(\frac{1}{\Delta x_{ieL}}\sum_{i=2}^{3}u_{iL}B_{i-1L}-\frac{1}{\Delta x_{ieR}}\sum_{i=2}^{3}u_{iR}B_{i-1R}\right)\frac{1}{\Delta x_{ieR}}d_{LR}^2\right)=0\\
&\frac{-2}{d_{LR}}\left(\omega_0^2\left(\sum_{i=1}^{3}u_{iL}B_{iL}-\sum_{i=1}^{3}u_{iR}B_{iR}\right)B_{3R}+\omega_1^2\left(\frac{1}{\Delta x_{ieL}}\sum_{i=2}^{3}u_{iL}B_{i-1L}-\frac{1}{\Delta x_{ieR}}\sum_{i=2}^{3}u_{iR}B_{i-1R}\right)B_{2R}\frac{1}{\Delta x_{ieR}}d_{LR}^2+\right.\\
&\left.\omega_2^2\left(\Delta x_{ieL}^{-2}u_{3L}-\Delta x_{ieR}^{-2}u_{3R}\right)\Delta x_{ieR}^{-2}d_{LR}^4\right)=0
\end{aligned}
\right.
$$

通过求解该线性方程组进行 $f(x)$ 与 $g(x)$ 的重构，需要注意的是，LU-SGS 得到的解误差较大, 需要 SGS(k) 进行求解，且 k=21。下面展示权重 $\omega_0=1,\omega_1=1,\omega_2=1,\omega_b=\frac{\omega_0}{\sqrt{2}}$, Nelem=8 时的重构图和精度分析图：



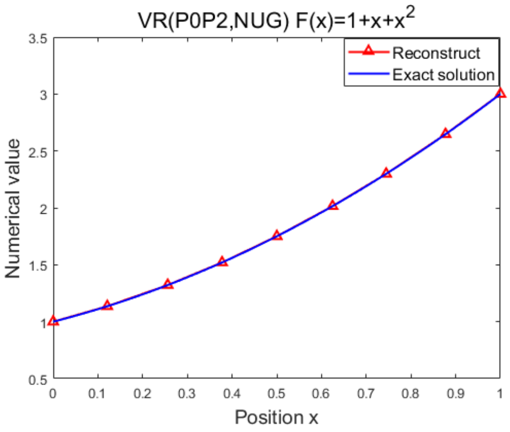
(a) f 重构



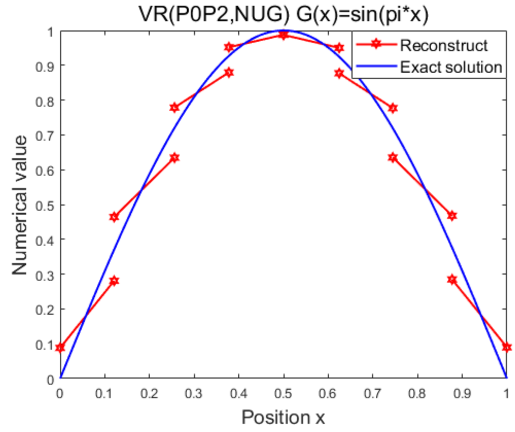
(b) g 重构

图 1: VR P0P2 重构 (LU-SGS)

调整权重系数以及边界面权重系数，测试重构精度，得到以下结论：

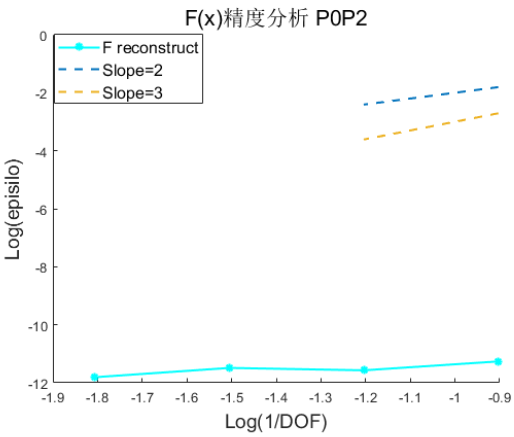


(a) f 重构

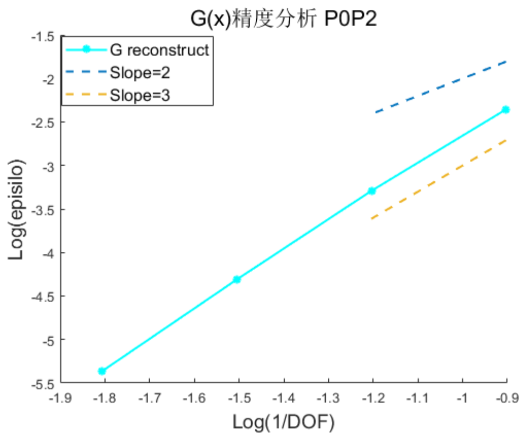


(b) g 重构

图 2: VR P0P2 重构 (SGS(21))



(a) f 精度分析



(b) g 精度分析

图 3: VR P0P2 精度分析

表 1: $F(x)$ 精度与 ω_0,ω_1,ω_2,ω_b 的关系

ω_0	ω_1	ω_2	ω_b	精度表现
0	—	—	—	差
—	0	—	—	差
—	—	0	—	差
—	—	—	$\downarrow 1$	$\uparrow$
—	—	$\uparrow 1$	—	$\uparrow$
—	$\uparrow 1$	—	—	$\uparrow$
$\uparrow 1$	—	—	—	$\uparrow$

表 2: $G(x)$ 精度与 ω_0,ω_1,ω_2,ω_b 的关系

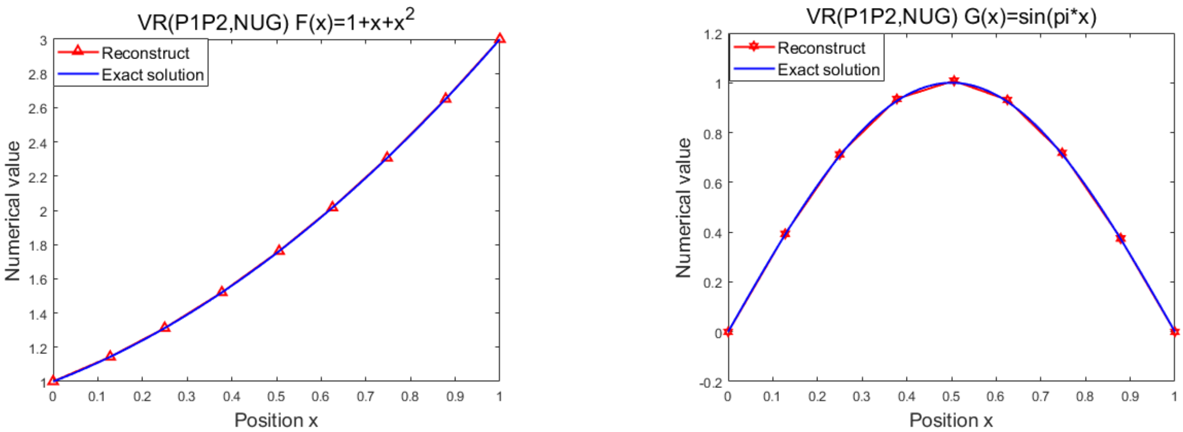
ω_0	ω_1	ω_2	ω_b	精度表现
0	—	—	—	差
—	—	—	$\downarrow 1$	$\uparrow$
—	—	$\uparrow 0.5$	—	$\uparrow$
—	$\uparrow 0.5$	—	—	$\uparrow$
$\uparrow 1$	—	—	—	$\uparrow$

解：P1P2

与 P0P2 类似，IJI 的定义不变，但是限制方程组改变：

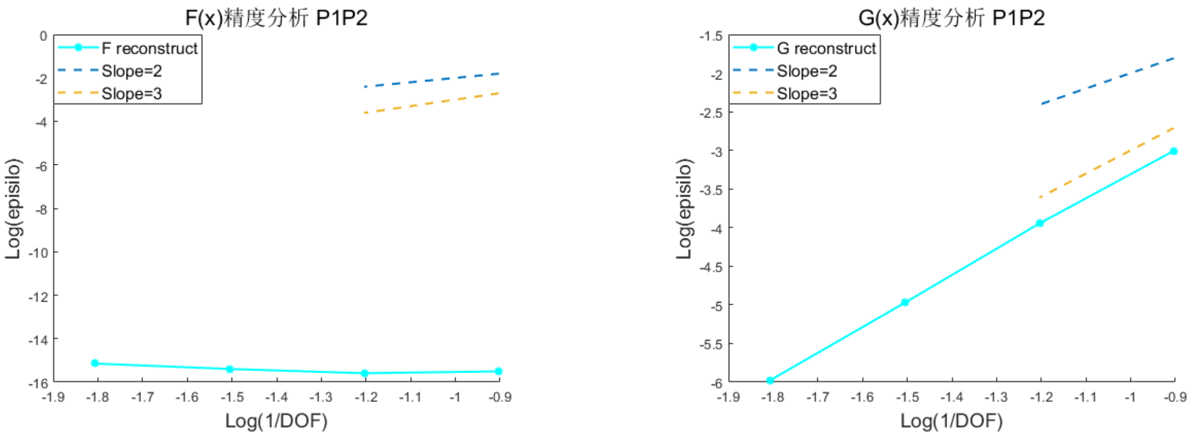
$$\begin{cases} \dfrac{\partial I_f}{\partial u_{3L}} = 0 \\ \dfrac{\partial I_f}{\partial u_{3R}} = 0 \end{cases}$$

该重构可用托马斯精确求解，下面展示权重 $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = \frac{\omega_0}{\sqrt{2}}$, Nelem=8 时的重构图和精度分析图：



(a) f 重构　**(b)** g 重构

图 4: VR P1P2 重构



(a) f 精度分析　**(b)** g 精度分析

图 5: VR P1P2 精度分析

调整权重系数以及边界面权重系数，测试重构精度，得到以下结论：

表 3: $F(x)$ 精度与 ω_0,ω_1,ω_2,ω_b 的关系 (P1P2)

ω_0	ω_1	ω_2	ω_b	精度表现
—	—	—	$\uparrow \frac{\omega_0}{\sqrt{2}}$	$\uparrow$
—	—	$\uparrow 1$	—	$\uparrow$
—	$\uparrow 0.5$	—	—	$\uparrow$
改变	—	—	—	几乎无影响

表 4: $G(x)$ 精度与 ω_0,ω_1,ω_2,ω_b 的关系 (P1P2)

ω_0	ω_1	ω_2	ω_b	精度表现
—	—	—	$\uparrow \frac{\omega_0}{\sqrt{2}}$	$\uparrow$
—	—	$\uparrow 1$	—	$\uparrow$
—	$\uparrow 1$	—	—	$\uparrow$
改变	—	—	—	几乎无影响

b) 解：

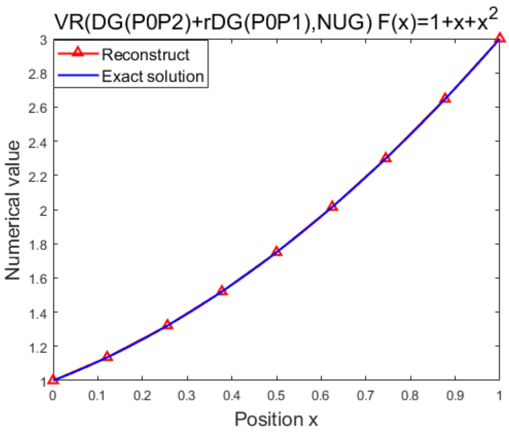
考虑 Hyperbolic rDG, 注意到

$$u=\begin{pmatrix}\varphi\\ v\end{pmatrix}=\begin{pmatrix}B_1 & B_2 & B_3\\ 0 & B_1\Delta x^{-1} & B_2\Delta x^{-1}\end{pmatrix}\begin{pmatrix}\overline{\varphi}\\ \overline{\varphi_x}\Delta x\\ \varphi_{xx}^{c,R}\Delta x^2\end{pmatrix}$$

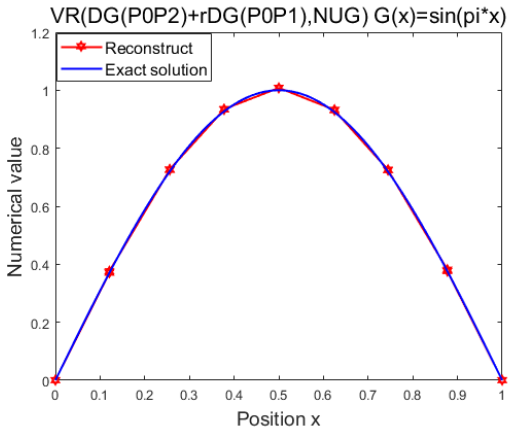
$\Rightarrow \begin{cases}\varphi_x=v\\ \varphi_{xx}=v_x\end{cases}$ 所以，若 $u_1=\overline{\varphi_i}, u_2=\overline{\varphi_x}\Delta x_i, u_3=\varphi_{xx}^{c,R}\Delta X_I^2$, 则 $\varphi=\sum_{i=1}^{3}u_iB_i$

$$I_f=\frac{1}{d_{LR}}\left(\omega_0^2\left[\varphi\right]^2+\omega_1^2\left[v\right]^2d_{LR}^2+\omega_2^2\left[v_x\right]^2d_{LR}^4\right)=\frac{1}{d_{LR}}\left(\omega_0^2\left[\varphi\right]^2+\omega_1^2\left[\varphi_x\right]^2d_{LR}^2+\omega_2^2\left[\varphi_{xx}\right]^2d_{LR}^4\right)$$

这与 P1P2 的 VR 是等价的，只不过 u_2 存储的量发生了改变。权重系数与边界系数对于重构精度的影响与 P1P2 的 VR 类似，这里不予展示。下面展示这种情况下权重 $\omega_0=1,\omega_1=1,\omega_2=1,\omega_b=\frac{\omega_0}{\sqrt{2}}$, Nelem=8 时的重构图和精度分析图：

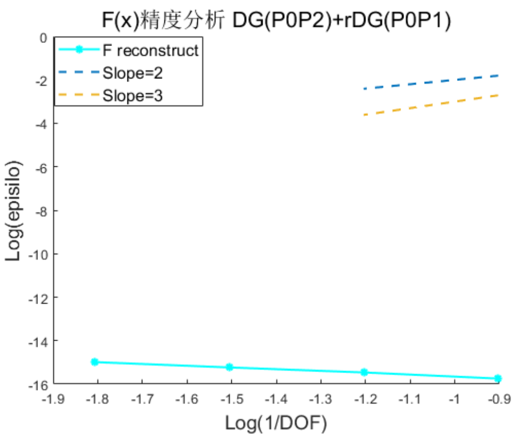


(a) f 重构

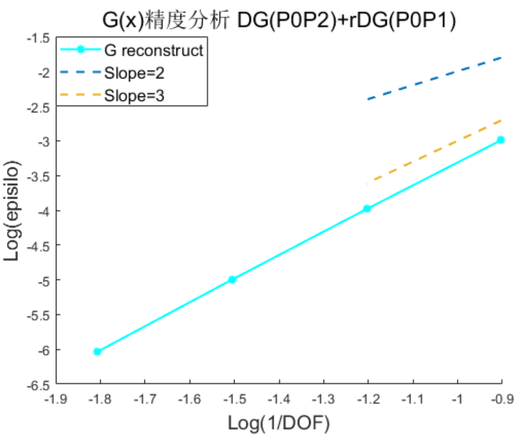


(b) g 重构

图 6: VR DG(P0P2)+rDG(P0P1)



(a) f 精度分析



(b) g 精度分析

图 7: VR DG(P0P2)+rDG(P0P1) 精度分析

二 附录

2 代码，仅展示部分

VRP0P2

```
clc
clear all
close all
% Pre-proceeding
Unit=8;endx=1;deltax=endx/Unit;numberx=Unit+1;omega0=1;omega1=1;omega2=0.5;omegab=omega0/sqrt(2);
%记录内点位置，上下浮动不超过百分之 5
Grid=zeros(1,numberx);
Deltax=zeros(1,Unit);
for i=2:numberx-1
Grid(1,i)=(i-1)*deltax+(0.1*rand(1)-0.05)*deltax;
end
Grid(1,numberx)=endx;
for i=2:numberx
Deltax(i-1)=Grid(1,i)-Grid(1,i-1);%记录每个单元的区间长度
end
f=@(x)1+x+x.^2;F=@(x)2.*x+1;
h=@(x)sin(pi*x);H=@(x)pi*cos(pi*x);
Unumsolution=zeros(1,Unit);
Ureconstruct=zeros(2*Unit,1);
A=sparse(1:2*Unit,1:2*Unit,0,2*Unit,2*Unit);
R=zeros(2*Unit,1);
Unumsolution1=zeros(1,2);
Unumsolution2=zeros(2,numberx-1);
Acc=zeros(3,4);a1=[1/8,1/16,1/32,1/64];a2=[1/8,1/16];

% Proceeding
%对 f
%initial
for i=1:numberx-1
Unumsolution(1,i)=(Grid(i+1)-Grid(i)+(Grid(i+1)^2-Grid(i)^2)/2+(Grid(i+1)^3-Grid(i)^3)/3)/(Grid(i+1)-Grid(i));
end

%构建大型分块稀疏矩阵
```

```
for iface=2:numberx-1
ieL=iface-1;xciL=0.5*(Grid(ieL)+Grid(ieL+1));
ieR=iface;xciR=0.5*(Grid(ieR)+Grid(ieR+1));
dLR=0.5*(Deltax(ieR)+Deltax(ieL));
B2L=(Grid(iface)-xciL)/Deltax(ieL);B2R=(Grid(iface)-xciR)/Deltax(ieR);
B3L=0.5*B2L^2-1/24;B3R=0.5*B2R^2-1/24;
%diag
A(2*ieL-1,2*ieL-1)=A(2*ieL-1,2*ieL-1)+2*(omega0^2*B2L^2+omega1^2*dLR^2/Deltax(ieL)^2)/dLR;
A(2*ieL-1,2*ieL)=A(2*ieL-1,2*ieL)+2*(omega0^2*B3L*B2L+omega1^2*dLR^2*B2L/Deltax(ieL)^2)/dLR;
A(2*ieL,2*ieL-1)=A(2*ieL,2*ieL-1)+2*(omega0^2*B2L*B3L+omega1^2*dLR^2*B2L/Deltax(ieL)^2)/dLR;
A(2*ieL,2*ieL)=A(2*ieL,2*ieL)+2*(omega0^2*B3L^2+omega1^2*dLR^2*B2L^2/Deltax(ieL)^2+omega2^2*dLR^4/Deltax(ieL)^4)/dLR;
A(2*ieR-1,2*ieR-1)=A(2*ieR-1,2*ieR-1)+2*(omega0^2*B2R^2+omega1^2*dLR^2/Deltax(ieR)^2)/dLR;
A(2*ieR-1,2*ieR)=A(2*ieR-1,2*ieR)+2*(omega0^2*B3R*B2R+omega1^2*dLR^2*B2R/Deltax(ieR)^2)/dLR;
A(2*ieR,2*ieR-1)=A(2*ieR,2*ieR-1)+2*(omega0^2*B2R*B3R+omega1^2*dLR^2*B2R/Deltax(ieR)^2)/dLR;
A(2*ieR,2*ieR)=A(2*ieR,2*ieR)+2*(omega0^2*B3R^2+omega1^2*dLR^2*B2R^2/Deltax(ieR)^2+omega2^2*dLR^4/Deltax(ieR)^4)/dLR;

%upper
A(2*ieL-1,2*ieR-1)=A(2*ieL-1,2*ieR-1)-2*(omega0^2*B2R*B2L+omega1^2*dLR^2/(Deltax(ieL)*Deltax(ieR)))/dLR;
A(2*ieL-1,2*ieR)=A(2*ieL-1,2*ieR)-2*(omega0^2*B3R*B2L+omega1^2*dLR^2*B2R/(Deltax(ieL)*Deltax(ieR)))/dLR;
A(2*ieL,2*ieR-1)=A(2*ieL,2*ieR-1)-2*(omega0^2*B2R*B3L+omega1^2*dLR^2*B2L/(Deltax(ieL)*Deltax(ieR)))/dLR;
A(2*ieL,2*ieR)=A(2*ieL,2*ieR)-2*(omega0^2*B3R*B3L+omega1^2*dLR^2*B2R*B2L/(Deltax(ieL)*Deltax(ieR))+omega2^2*dLR^4/(Deltax(ieL)^2*Deltax(ieR)^2))/dLR;
%lower
A(2*ieR-1,2*ieL-1)=A(2*ieR-1,2*ieL-1)-2*(omega0^2*B2L*B2R+omega1^2*dLR^2/(Deltax(ieL)*Deltax(ieR)))/dLR;
A(2*ieR-1,2*ieL)=A(2*ieR-1,2*ieL)-2*(omega0^2*B3L*B2R+omega1^2*dLR^2*B2L/(Deltax(ieR)*Deltax(ieL)))/dLR;
A(2*ieR,2*ieL-1)=A(2*ieR,2*ieL-1)-2*(omega0^2*B2L*B3R+omega1^2*dLR^2*B2R
```

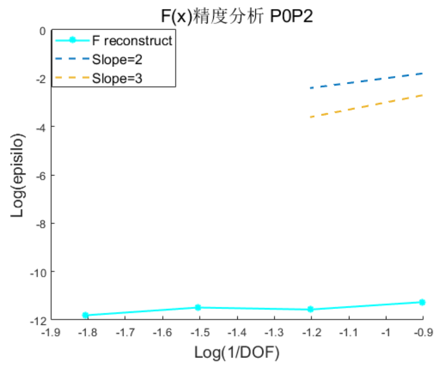
```
/(Deltax(ieR)*Deltax(ieL)))/dLR;
A(2*ieR,2*ieL)=A(2*ieR,2*ieL)-2*(omega0^2*B3L*B3R+omega1^2*dLR^2*B2L*B2R/(Deltax(ieR)*Deltax(ieL))+omega2^2*dLR^4/(Deltax(ieR)^2*Deltax(ieL)^2))/dLR;

%RHS
R(2*ieL-1)=R(2*ieL-1)-2*omega0^2*(Unumsolution(ieL)-Unumsolution(ieR))*B2L/dLR;
R(2*ieL)=R(2*ieL)-2*omega0^2*(Unumsolution(ieL)-Unumsolution(ieR))*B3L/dLR;
R(2*ieR-1)=R(2*ieR-1)+2*omega0^2*(Unumsolution(ieL)-Unumsolution(ieR))*B2R/dLR;
R(2*ieR)=R(2*ieR)+2*omega0^2*(Unumsolution(ieL)-Unumsolution(ieR))*B3R/dLR;
end

%B.C
%left
iface=1;
ieR=iface;
xciR=0.5*(Grid(ieR)+Grid(ieR+1));
B2R=(Grid(iface)-xciR)/Deltax(ieR);
B3R=0.5*B2R^2-1/24;
A(2*ieR-1,2*ieR-1)=A(2*ieR-1,2*ieR-1)+4*omegab^2*B2R^2/Deltax(ieR);
A(2*ieR-1,2*ieR)=A(2*ieR-1,2*ieR)+4*omegab^2*B2R*B3R/Deltax(ieR);
A(2*ieR,2*ieR-1)=A(2*ieR,2*ieR-1)+4*omegab^2*B2R*B3R/Deltax(ieR);
A(2*ieR,2*ieR)=A(2*ieR,2*ieR)+4*omegab^2*B3R^2/Deltax(ieR);

R(2*ieR-1)=R(2*ieR-1)+4*omegab^2*(1-Unumsolution(ieR))*B2R/Deltax(ieR);
R(2*ieR)=R(2*ieR)+4*omegab^2*(1-Unumsolution(ieR))*B3R/Deltax(ieR);

%Right
iface=numberx;
ieL=iface-1;
xciL=0.5*(Grid(ieL)+Grid(ieL+1));
B2L=(Grid(iface)-xciL)/Deltax(ieL);
B3L=0.5*B2L^2-1/24;

A(2*ieL-1,2*ieL-1)=A(2*ieL-1,2*ieL-1)+4*omegab^2*B2L^2/Deltax(ieL);
A(2*ieL-1,2*ieL)=A(2*ieL-1,2*ieL)+4*omegab^2*B2L*B3L/Deltax(ieL);
```

```
A(2*ieL,2*ieL-1)=A(2*ieL,2*ieL-1)+4*omegab^2*B2L*B3L/Deltax(ieL);
A(2*ieL,2*ieL)=A(2*ieL,2*ieL)+4*omegab^2*B3L^2/Deltax(ieL);

R(2*ieL-1)=R(2*ieL-1)-4*omegab^2*(Unumsolution(ieL)-3)*B2L/Deltax(ieL);
R(2*ieL)=R(2*ieL)-4*omegab^2*(Unumsolution(ieL)-3)*B3L/Deltax(ieL);



%LU-SGS 解三对角矩阵
%取出我们所需要的 D
D=zeros(2*Unit,2*Unit);
for iface=2:numberx
ieL=iface-1;
D(2*ieL-1:2*ieL,2*ieL-1:2*ieL)=A(2*ieL-1:2*ieL,2*ieL-1:2*ieL);
end
%取出我们所需要的 L
L=zeros(2*Unit,2*Unit);
for iface=2:numberx-1
ieR=iface;
ieL=iface-1;
L(2*ieR-1:2*ieR,2*ieL-1:2*ieL)=A(2*ieR-1:2*ieR,2*ieL-1:2*ieL);
end

%取出我们所需要的 U
U=zeros(2*Unit,2*Unit);
for iface=2:numberx-1
ieR=iface;
ieL=iface-1;
U(2*ieL-1:2*ieL,2*ieR-1:2*ieR)= A(2*ieL-1:2*ieL,2*ieR-1:2*ieR);
end
b=R;%用来存储最初的 rhs
Ureconstruct0=zeros(2*Unit,1);
for k=1:30%k 表示 SGS(k)
%Forward sweep
ie=1;
Ureconstruct(ie:ie+1,1)=D(ie:ie+1,ie:ie+1)\R(ie:ie+1,1);
for ie=2:numberx-1
R(2*ie-1:2*ie,1)=R(2*ie-1:2*ie,1)-L(2*ie-1:2*ie,2*(ie-1)-1:2*(ie-1))*Ureconstruct(2*(ie-1)-1:2*(ie-1),1);
Ureconstruct(2*ie-1:2*ie,1)=D(2*ie-1:2*ie,2*ie-1:2*ie)\R(2*ie-1:2*ie,1);
```

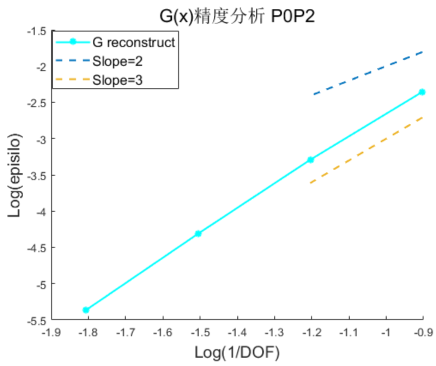
```
end
%Backward sweep
for ie=1:numberx-1
R(2*ie-1:2*ie,1)= D(2*ie-1:2*ie,2*ie-1:2*ie)*Ureconstruct(2*ie-1:2*ie,1);
end

ie=numberx-1;
Ureconstruct(2*ie-1:2*ie)=D(2*ie-1:2*ie,2*ie-1:2*ie)\R(2*ie-1:2*ie,1);
for ie=numberx-2:-1:1
R(2*ie-1:2*ie,1)=R(2*ie-1:2*ie,1)-U(2*ie-1:2*ie,2*(ie+1)-1:2*(ie+1))*Ureconstruct(2*(ie+1)-1:2*(ie+1),1);
Ureconstruct(2*ie-1:2*ie,1)=D(2*ie-1:2*ie,2*ie-1:2*ie)\R(2*ie-1:2*ie,1);
end
deltaUreconstruct=Ureconstruct;
Ureconstruct=Ureconstruct0+Ureconstruct;
if max(deltaUreconstruct)<10^(-10)
break;
end
%重新整理 R
R=b-A*Ureconstruct;
Ureconstruct0=Ureconstruct;
end
% Post-proceeding
figure
k=1;
x=Grid(k):1*(Grid(k+1)-Grid(k)):Grid(k+1);
xci=(Grid(k+1)+Grid(k))/2;
p=@(x)Unumsolution(1,k)+Ureconstruct(2*k-1,1)*(x-xci)/Deltax(k)+Ureconstruct(2*k,1)*(0.5*((x-xci)/Deltax(k)).^2-1/24);
y=p(x);
plot(x,y,'-r^','linewidth',1.5);hold on
H1=plot(x,y,'-r^','linewidth',1.5);hold on

for k=2:numberx-1
x=Grid(k):1*(Grid(k+1)-Grid(k)):Grid(k+1);
xci=(Grid(k+1)+Grid(k))/2;
p=@(x)Unumsolution(1,k)+Ureconstruct(2*k-1,1)*(x-xci)/Deltax(k)+Ureconstruct(2*k,1)*(0.5*((x-xci)/Deltax(k)).^2-1/24);
y=p(x);
```

```
plot(x,y,'-r^','linewidth',1.5);
end

hold on
x=Grid(1):0.01*(Grid(numberx)-Grid(1)):Grid(numberx);
plot(x,f(x),'-b','linewidth',1.5);
H2=plot(x,f(x),'-b','linewidth',1.5);
lgd=legend([H1,H2],'Reconstruct','Exact solution');
lgd.FontSize=12;
xlabel('Position x','fontsize',14)
ylabel('Numerical value','fontsize',14)
title('VR(POP2,NUG) F(x)=1+x+x^2','fontsize',16)
hold off

%计算精度
Acc(1,1)=Accuracy(8);
Acc(1,2)=Accuracy(16);
Acc(1,3)=Accuracy(32);
Acc(1,4)=Accuracy(64);
for k=1:3
accuracyf(k)=(log10(Acc(1,k+1))-log10(Acc(1,k)))./(log10(a1(1,k+1))-
    log10(a1(1,k)));
end

figure
hold on
plot(log10(a1),log10(Acc(1,:)),'-c*','linewidth',1.5)
H1=plot(log10(a1),log10(Acc(1,:)),'-c*','linewidth',1.5);

H2=plot(log10(a2),2*log10(a2),'--','linewidth',1.5);
plot(log10(a2),3*log10(a2),'--','linewidth',1.5)
H3=plot(log10(a2),3*log10(a2),'--','linewidth',1.5);
lgd=legend([H1,H2,H3],'F reconstruct','Slope=2','Slope=3');
lgd.FontSize=12;
xlabel('Log(1/DOF)','fontsize',14)
ylabel('Log(episilo)','fontsize',14)
title('F(x)精度分析 POP2','fontsize',16)
```

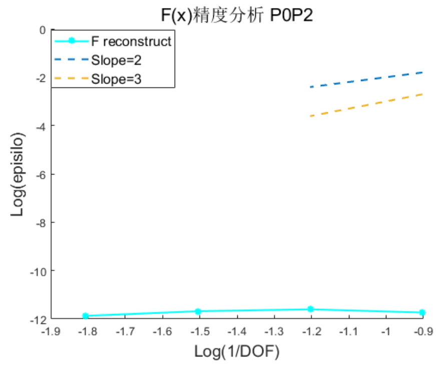
2 部分精度比较图



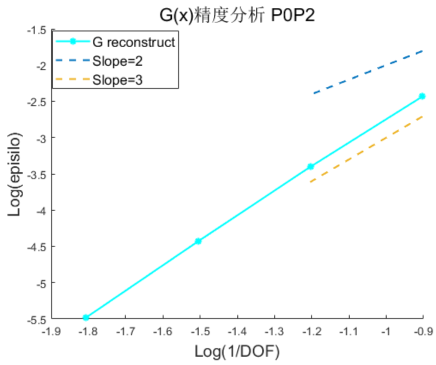
(a) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = \frac{\omega_0}{\sqrt{2}}$



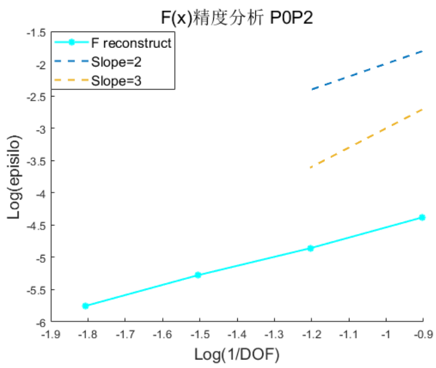
(b) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = \frac{\omega_0}{\sqrt{2}}$



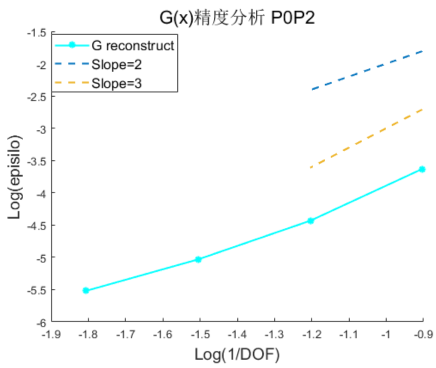
(c) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = 1$



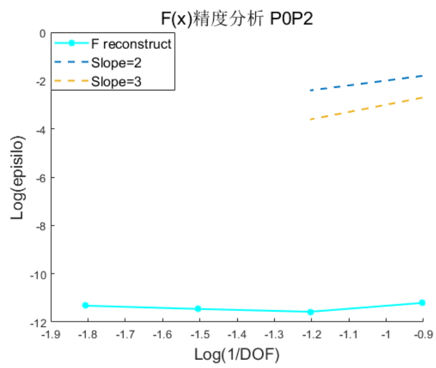
(d) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = 1$



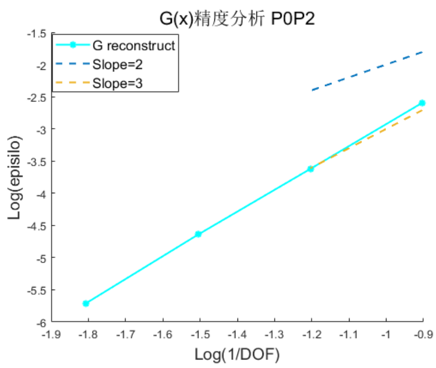
(e) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0, \omega_b = \frac{\omega_0}{\sqrt{2}}$



(f) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0, \omega_b = \frac{\omega_0}{\sqrt{2}}$

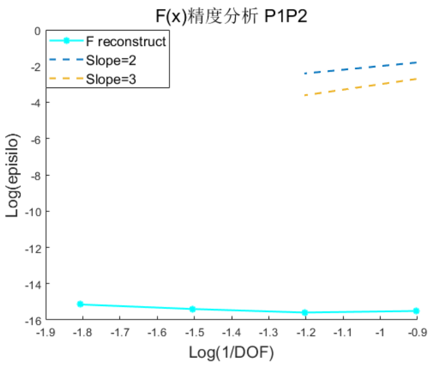


(g) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0.5, \omega_b = \frac{\omega_0}{\sqrt{2}}$

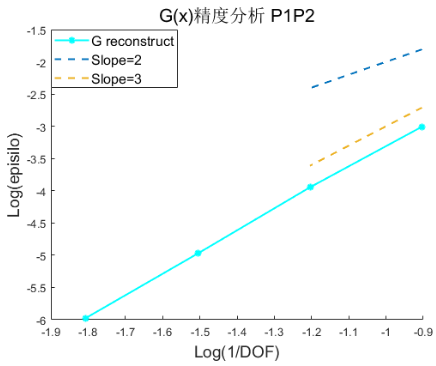


(h) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0.5, \omega_b = \frac{\omega_0}{\sqrt{2}}$

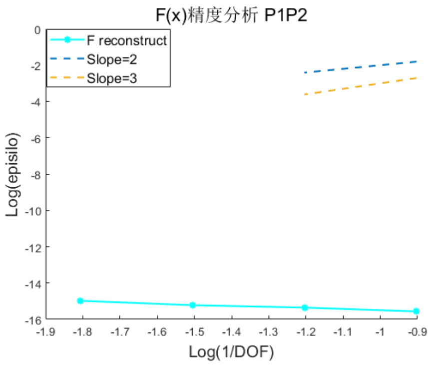
图 8: VR 精度分析 (P0P2 调整权重系数)



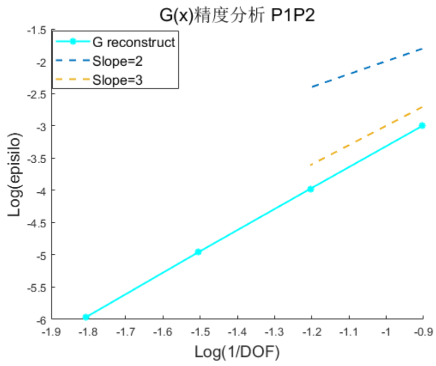
(a) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = \frac{\omega_0}{\sqrt{2}}$



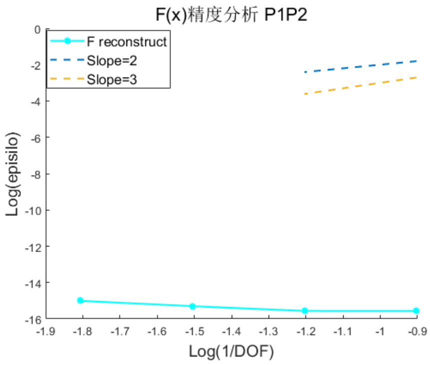
(b) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = \frac{\omega_0}{\sqrt{2}}$



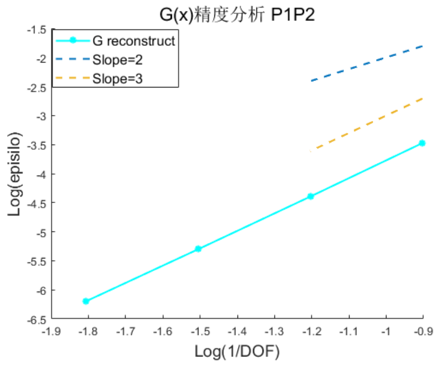
(c) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = 1$



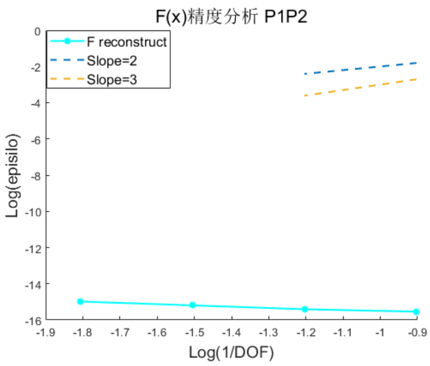
(d) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 1, \omega_b = 1$



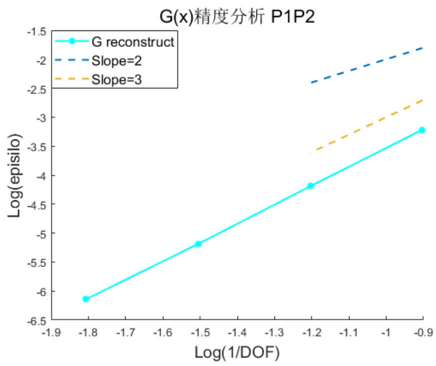
(e) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0, \omega_b = \frac{\omega_0}{\sqrt{2}}$



(f) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0, \omega_b = \frac{\omega_0}{\sqrt{2}}$



(g) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0.5, \omega_b = \frac{\omega_0}{\sqrt{2}}$



(h) $\omega_0 = 1, \omega_1 = 1, \omega_2 = 0.5, \omega_b = \frac{\omega_0}{\sqrt{2}}$

图 9: VR 精度分析 (P1P2 调整权重系数)