```
In[ ]:= SetDirectory@NotebookDirectory[];
        设置目录          当前笔记本的目录
        Import["QLanczos_package.m"];
        导入
```

Parameters

```
In[ ]:= th = 10;(*multiple of noise*)
        d = 5;
        Id = IdentityMatrix[d];
             单位矩阵
        κ = 0.1;
        η = 10.^-15;(*machine precision*)

In[ ]:= MList = Table[10.^j, {j, 4, 20, 1}];
                表格
        (*the measurement number for a real matrx element is M*)
        rep = 100;(*replications*)
```

Model

```
In[ ]:= Ham = HeisenbergHam;
```

Spectrum

```
In[ ]:= {Λ, U} = funSpectrum[Ham];
        HamNorm = Max[Abs[Λ]]
                  ···  绝对值
        Λ = Λ / HamNorm;
        Eg = Λ[[1]]
Out[ ]= 17.0321

Out[ ]= -1.

In[ ]:= htot = 27. / HamNorm
Out[ ]= 1.58524
```

Reference state

```
In[ ]:= φ = φHeisenberg;
        φ = Flatten[Conjugate[U].φ];
            压平       共轭
        probφ = Abs[φ]^2;
                绝对值
```

```
pg = probφ[[1]] (*pg>10^-3*)
ER = Total[probφ * Λ];
     └总计
∈R = ER - Eg
```

```
0.682614
```

```
0.119312
```

Power

```
E0 = Eg + 1.;
{Hmat, Smat} = funMatP[Λ, E0, d, probφ];
```

```
EB = Hmat[[d, d]] / Smat[[d, d]];
∈B = EB - Eg(*used to identify τ for GP, ITE and F*)
```

```
0.0072981
```

```
{EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
∈K = EK - Eg(*10^-9<∈K<10^-2*)
```

```
0.000390209
```

```
costH = 1.;
costS = 1.;
∈PList = funThrPracGP[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Chebyshev Polynomial

```
E0 = 0.;
{Hmat, Smat} = funMatCP[Λ, E0, d, probφ, htot];
```

```
costH = 1.;
costS = 1.;
∈CPList = funThrPracF[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Gaussian-Power

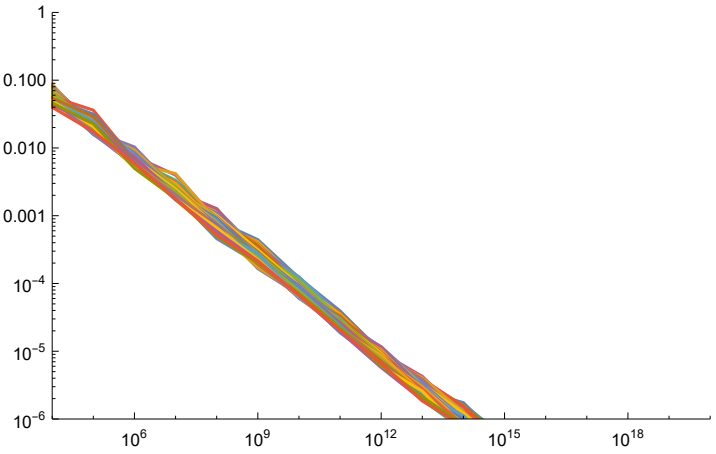
```
In[•]:= τMIN = 0;
        τMAX = 64;
        While[True,
        Whil··· 真
          τ = (τMIN + τMAX) / 2.;
          {Hmat, Smat} = funMatGP[Λ, Eg, τ, 1, probφ, htot];
          EK = Hmat[[1, 1]] / Smat[[1, 1]];
          err = EK - Eg;
          If[err > ϵB, τMIN = τ];
          如果
          If[err < ϵB, τMAX = τ];
          如果
          (*Print[{err,τMIN,τMAX}];*)
            打印
          If[Abs[err - ϵB] < 10^-10, Break[]];
          ··· 绝对值                跳出循环
        ];
        τ
Out[•]= 6.34638

In[•]:= E0 = Eg;
        {Hmat, Smat} = funMatGP[Λ, E0, τ, d, probφ, htot];

In[•]:= costH = htot;
        costS = 1.;
        ϵGPList = funThrPracF[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];(*rescaled*)
```

Gaussian-Power with different E0

```
In[•]:= δList = Table[0.002 * j, {j, -50, 50}];
              表格
        δCurves = {};
        Do[
        Do循环
          δ = δList[[j]];
          E0 = Eg + δ;
          {Hmat, Smat} = funMatGP[Λ, E0, τ, d, probφ, htot];
          ϵGPList = funThrPracF[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
          ϵGPListκ = funExtract[ϵGPList, MList, rep, κ];
          AppendTo[δCurves, Transpose[{MList, ϵGPListκ}]];
          附加                  转置
          , {j, 1, Length[δList]}];
                   长度
```

In[•]:=
```
PR = {{10^4, 10^20}, {10^-6, 10^0}};
ListLogLogPlot[δCurves, PlotRange → PR, Joined → True]
```
点集的双对数图 绘制范围 连接点 真

Out[•]=



Inverse Power

In[•]:=
```
E0 = Eg - 1.;
{Hmat, Smat} = funMatIP[Λ, E0, d, probφ];
```

In[•]:=
```
costH = 1.;
costS = 1.;
ϵIPList = funThrPracGP[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Imaginary-time evolution

In[•]:=
```
τMIN = 0;
τMAX = 64;
While[True,
  τ = (τMIN + τMAX) / 2.;
  {Hmat, Smat} = funMatITE[Λ, Eg, τ, d, probφ];
  EK = Hmat[[d, d]] / Smat[[d, d]];
  err = EK - Eg;
  If[err > ϵB, τMIN = τ];
  If[err < ϵB, τMAX = τ];
  (*Print[{err,τMIN,τMAX}];*)
  If[Abs[err - ϵB] < 10^-10, Break[]];
 ];
τ
```
Whil… 真 如果 如果 打印 … 绝对值 跳出循环

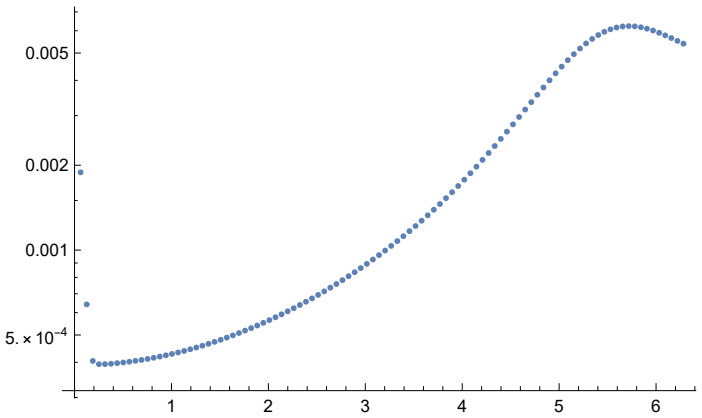
Out[•]=
```
1.1768
```

```
In[ ]:= E0 = Eg;
        {Hmat, Smat} = funMatITE[Λ, E0, τ, d, probφ];

In[ ]:= costH = 1.;
        costS = 1.;
        ϵITEList = funThrPracGP[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Real-time evolution

```
In[ ]:= ΔtList = Table[2. * π / 100 j, {j, 1, 100}];
                 表格

        ϵKList = ConstantArray[0, Length[ΔtList]];
                 常量数组          长度

        Do[
        Do循环
         Δt = ΔtList[[j]];
         {Hmat, Smat} = funMatRTE[Λ, Eg, Δt, d, probφ];
         {EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
         err = EK - Eg;
         ϵKList[[j]] = err;
         , {j, 1, Length[ΔtList]}]
                  长度

        Δt = ΔtList[[Position[ϵKList, Min[ϵKList]][[1, 1]]]]
                    位置          最小值

        ListLogPlot[Transpose[{ΔtList, ϵKList}], PlotRange → Full]
        点集的对数图  转置                        绘制范围      全范围

Out[ ]= 0.251327
```

Out[ ]=




```
In[ ]:= E0 = Eg;
        {Hmat, Smat} = funMatRTE[Λ, E0, Δt, d, probφ];

In[ ]:= costH = 1.;
        costS = 1.;
        ϵRTEList = funThrPracRTE[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Filter

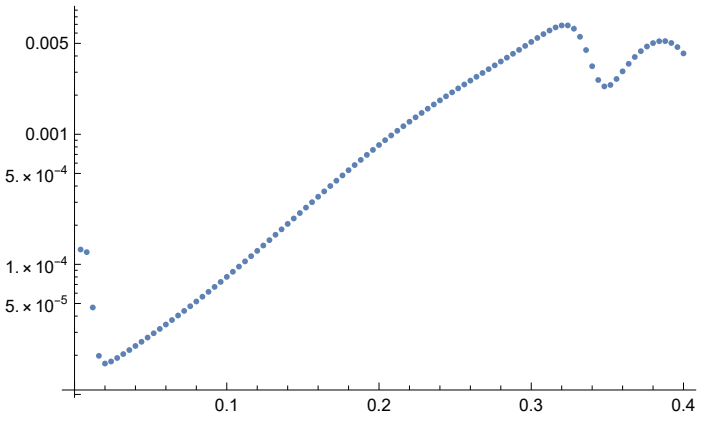
In[ ]:=
```
τMIN = 0;
τMAX = 64;
While[True,
 τ = (τMIN + τMAX) / 2.;
 {Hmat, Smat} = funMatF[Λ, Eg, 0, τ, 1, probφ];
 EK = Hmat[[1, 1]] / Smat[[1, 1]];
 err = EK - Eg;
 If[err > ϵB, τMIN = τ];
 If[err < ϵB, τMAX = τ];
 (*Print[{err,τMIN,τMAX}];*)
 If[Abs[err - ϵB] < 10^-10, Break[]];
 ];
τ
```

Out[ ]=
```
11.2447
```

In[ ]:=
```
ΔEList = Table[2. / (d * 100) * j, {j, 1, 100}];
          表格

ϵKList = ConstantArray[0, Length[ΔEList]];
          常量数组              长度

Do[(
Do循环
  ΔE = ΔEList[[j]];
  {Hmat, Smat} = funMatF[Λ, Eg, ΔE, τ, d, probφ];
  {EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
  err = EK - Eg;
  ϵKList[[j]] = err;
 ), {j, 1, Length[ΔEList]}]
           长度

ΔE = ΔEList[[Position[ϵKList, Min[ϵKList]][[1, 1]]]]
              位置              最小值

ListLogPlot[Transpose[{ΔEList, ϵKList}], PlotRange → Full]
点集的对数图  转置                        绘制范围      全范围
```

Out[ ]=
```
0.02
```

Out[ ]=



In[ ]:=
```
E0 = Eg;
{Hmat, Smat} = funMatF[Λ, E0, ΔE, τ, d, probφ];
```

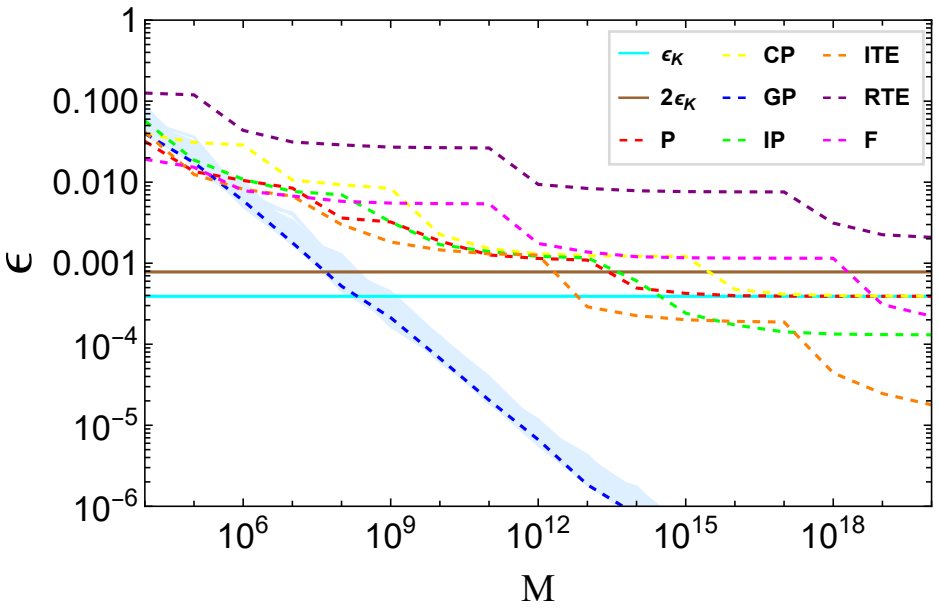
In[ ]:=
```
costH = 1.;
costS = 1.;
ϵFList = funThrPracF[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];
```

Plot

In[ ]:=
```
ϵPListκ = funExtract[ϵPList, MList, rep, κ];
ϵCPListκ = funExtract[ϵCPList, MList, rep, κ];
ϵGPListκ = funExtract[ϵGPList, MList, rep, κ];
ϵIPListκ = funExtract[ϵIPList, MList, rep, κ];
ϵITEListκ = funExtract[ϵITEList, MList, rep, κ];
ϵRTEListκ = funExtract[ϵRTEList, MList, rep, κ];
ϵFListκ = funExtract[ϵFList, MList, rep, κ];
```

In[•]:=
```
PR = {{10^4, 10^20}, {10^-6, 10^0}};
plot1 = ListLogLogPlot[δCurves, PlotRange → PR,
        点集的双对数图          绘制范围
    Joined → True, PlotStyle → Table[LightBlue, Length[δCurves]],
    连接点   真    绘图样式      表格   浅蓝色      长度
    Frame → True, FrameStyle → Directive[Black, Thickness[0.002]],
    边框    真    边框样式      指令       黑色   粗细
    FrameTicksStyle → Directive[Black, Thickness[0.002]], FrameLabel → {"M", "ϵ"}];
    边框刻度样式          指令       黑色   粗细                  边框标签
plot2 = ListLogLogPlot[{Transpose[{MList, 0. * MList + 1. * ϵK}],
        点集的双对数图          转置
     Transpose[{MList, 0. * MList + 2. * ϵK}], Transpose[{MList, ϵPListκ}],
     转置                                      转置
     Transpose[{MList, ϵCPListκ}], Transpose[{MList, ϵGPListκ}],
     转置                          转置
     Transpose[{MList, ϵIPListκ}], Transpose[{MList, ϵITEListκ}],
     转置                          转置
     Transpose[{MList, ϵRTEListκ}], Transpose[{MList, ϵFListκ}]},
     转置                           转置
    PlotRange → PR, Joined → True, PlotStyle → {{Thickness[0.004], Cyan},
    绘制范围        连接点   真    绘图样式      粗细              蓝绿色
      {Thickness[0.004], Brown}, {Thickness[0.004], Red, Dashed},
       粗细              棕色      粗细              红色 虚线
      {Thickness[0.004], Yellow, Dashed}, {Thickness[0.004], Blue, Dashed},
       粗细              黄色      虚线      粗细              蓝色 虚线
      {Thickness[0.004], Green, Dashed}, {Thickness[0.004], Orange, Dashed},
       粗细              绿色      虚线      粗细              橙色      虚线
      {Thickness[0.004], Purple, Dashed}, {Thickness[0.004], Magenta, Dashed}},
       粗细              紫色      虚线      粗细              品红色    虚线
    Frame → True, FrameStyle → Directive[Black, Thickness[0.002]],
    边框    真    边框样式      指令       黑色   粗细
    FrameTicksStyle → Directive[Black, Thickness[0.002]], FrameLabel → {"M", "ϵ"},
    边框刻度样式          指令       黑色   粗细                  边框标签
    LabelStyle → {FontSize → 18, FontFamily → "Arial"}, ImageSize → 500, PlotLegends →
    标签样式          字体大小          字体系列          图像尺寸          绘图的图例
     Placed[LineLegend[{"ϵK", "2ϵK", "P", "CP", "GP", "IP", "ITE", "RTE", "F"},
     放置    线的图例
       LegendFunction → (Framed[#, FrameStyle → LightGray] &), LegendMarkerSize →
       图例函数          加边框    边框样式      浅灰色          图例标记尺寸
        {16, 8}, LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"},
                 标签样式          黑色   粗体   字体大小          字体系列
       LegendMargins → 0, LegendLayout → {"Column", 3}], {0.79, 0.84}}];
       图例边幅          图例布局          列
Fig = Show[plot1, plot2,
      显示
  LabelStyle → {FontSize → 18, FontFamily → "Arial"}, ImageSize → 500]
  标签样式          字体大小          字体系列          图像尺寸
```

Out[ ]=

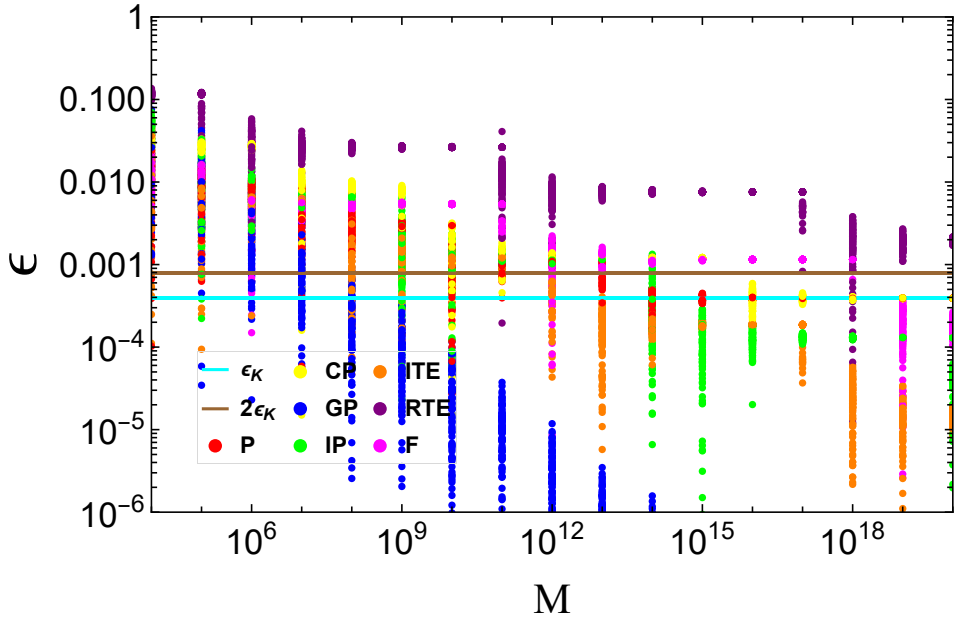


In[ ]:=

```
lleg1 = LineLegend[{Cyan}, {"ϵK"}, LegendMarkerSize → {14, 7},
        线的图例      蓝绿色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
lleg2 = LineLegend[{Brown}, {"2ϵK"}, LegendMarkerSize → {14, 7},
        线的图例      棕色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg1 = PointLegend[{Red}, {"P"}, LegendMarkerSize → {14, 7},
        点的图例      红色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg2 = PointLegend[{Yellow}, {"CP"}, LegendMarkerSize → {14, 7},
        点的图例      黄色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg3 = PointLegend[{Blue}, {"GP"}, LegendMarkerSize → {14, 7},
        点的图例      蓝色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg4 = PointLegend[{Green}, {"IP"}, LegendMarkerSize → {14, 7},
        点的图例      绿色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg5 = PointLegend[{Orange}, {"ITE"}, LegendMarkerSize → {14, 7},
        点的图例      橙色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg6 = PointLegend[{Purple}, {"RTE"}, LegendMarkerSize → {14, 7},
        点的图例      紫色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
pleg7 = PointLegend[{Magenta}, {"F"}, LegendMarkerSize → {14, 7},
        点的图例      品红色          图例标记尺寸
   LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
   标签样式          黑色   粗体   字体大小          字体系列                图例边幅
```

```
Fig2 =
 Legended[Show[Table[ListLogLogPlot[{Transpose[{MList, 0. * MList + 1. * ϵK}],
 图例 显示 表格 点集的双对数图 转置
      Transpose[{MList, 0. * MList + 2. * ϵK}], Transpose[{MList, ϵPList[[i]]}],
      转置 转置
      Transpose[{MList, ϵCPList[[i]]}], Transpose[{MList, ϵGPList[[i]]}],
      转置 转置
      Transpose[{MList, ϵIPList[[i]]}], Transpose[{MList, ϵITEList[[i]]}],
      转置 转置
      Transpose[{MList, ϵRTEList[[i]]}], Transpose[{MList, ϵFList[[i]]}]}, PlotRange → PR,
      转置 转置 绘制范围
    Joined → {True, True, False, False, False, False, False, False, False},
    连接点 真 真 假 假 假 假 假 假 假
    Frame → True, FrameStyle → Directive[Black, Thickness[0.002]], FrameTicksStyle →
    边框 真 边框样式 指令 黑色 粗细 边框刻度样式
     Directive[Black, Thickness[0.002], 18], FrameLabel → {"M", "ϵ"},
     指令 黑色 粗细 边框标签
    LabelStyle → {FontSize → 22, FontFamily → "Arial"}, ImageSize → 500, PlotStyle →
    标签样式 字体大小 字体系列 图像尺寸 绘图样式
     {Cyan, Brown, Red, Yellow, Blue, Green, Orange, Purple, Magenta}], {i, 1, rep}]],
     蓝绿色 棕色 红色 黄色 蓝色 绿色 橙色 紫色 品红色
 Placed[Grid[{{lleg1, pleg2, pleg5}, {lleg2, pleg3, pleg6}, {pleg1, pleg4, pleg7}}],
 放置 格子
   Alignment → Left, Frame → True, FrameStyle → LightGray], {{0.22, 0.45}, {0.5, 1.5}}]]
 对齐 左 边框 真 边框样式 浅灰色
```

Out[ ]=




```
In[ ]:= Export["C:\\Users\\John\\Desktop\\Revise\\Second
        导出 常量
    Revision\\Thresholding comparison th=10.pdf", Fig];
```