

```
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 matrix 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
```

```

In[ ]:= pg = probφ[[1]] (*pg>10^-3*)
      ER = Total[probφ * Δ];
           |总计
      eR = ER - Eg
Out[ ]:= 0.682614

Out[ ]:= 0.119312

```

Power

```

In[ ]:= E0 = Eg + 1.;
      {Hmat, Smat} = funMatP[Δ, E0, d, probφ];

In[ ]:= EB = Hmat[[d, d]] / Smat[[d, d]];
      eB = EB - Eg (*used to identify τ for GP, ITE and F*)
Out[ ]:= 0.0072981

In[ ]:= {EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
      eK = EK - Eg (*10^-9<eK<10^-2*)
Out[ ]:= 0.000390209

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

```

Chebyshev Polynomial

```

In[ ]:= E0 = 0.;
      {Hmat, Smat} = funMatCP[Δ, E0, d, probφ, htot];

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

```

Gaussian-Power

```

In[ ]:=  $\tau$ MIN = 0;
 $\tau$ MAX = 64;
While[True,
  |While... |真
     $\tau$  = ( $\tau$ MIN +  $\tau$ MAX) / 2.;
    {Hmat, Smat} = funMatGP[ $\Lambda$ , Eg,  $\tau$ , 1, prob $\phi$ , htot];
    EK = Hmat[[1, 1]] / Smat[[1, 1]];
    err = EK - Eg;
    If[err >  $\epsilon$ B,  $\tau$ MIN =  $\tau$ ];
    |如果
    If[err <  $\epsilon$ B,  $\tau$ MAX =  $\tau$ ];
    |如果
    (*Print[{err,  $\tau$ MIN,  $\tau$ MAX}];*)
    |打印
    If[Abs[err -  $\epsilon$ B] < 10-10, Break[]];
    |... |绝对值 |跳出循环
  ];
 $\tau$ 

```

Out[]:= 6.34638

```

In[ ]:= E0 = Eg;
{Hmat, Smat} = funMatGP[ $\Lambda$ , E0,  $\tau$ , d, prob $\phi$ , htot];

In[ ]:= costH = htot;
costS = 1.;
 $\epsilon$ GPList = funThrPracF[MList, rep, Hmat, Smat, d, costH, costS, th, Eg]; (*rescaled*)

```

Inverse Power

```

In[ ]:= E0 = Eg - 1.;
{Hmat, Smat} = funMatIP[ $\Lambda$ , E0, d, prob $\phi$ ];

In[ ]:= costH = 1.;
costS = 1.;
 $\epsilon$ IPList = funThrPracGP[MList, rep, Hmat, Smat, d, costH, costS, th, Eg];

```

Imaginary-time evolution

```

In[ ]:=  $\tau$ MIN = 0;
 $\tau$ MAX = 64;
While[True,
  _While... 真
   $\tau$  = ( $\tau$ MIN +  $\tau$ MAX) / 2.;
  {Hmat, Smat} = funMatITE[ $\Lambda$ , Eg,  $\tau$ , d, prob $\phi$ ];
  EK = Hmat[[d, d]] / Smat[[d, d]];
  err = EK - Eg;
  If[err >  $\epsilon$ B,  $\tau$ MIN =  $\tau$ ];
  _如果
  If[err <  $\epsilon$ B,  $\tau$ MAX =  $\tau$ ];
  _如果
  (*Print[{err,  $\tau$ MIN,  $\tau$ MAX}];*)
  _打印
  If[Abs[err -  $\epsilon$ B] < 10-10, Break[]];
  _... 绝对值      _跳出循环
];
 $\tau$ 

Out[ ]:= 1.1768

In[ ]:= E0 = Eg;
{Hmat, Smat} = funMatITE[ $\Lambda$ , E0,  $\tau$ , d, prob $\phi$ ];

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

```

Real-time evolution

```

In[ ]:= ΔtList = Table[ $\frac{2. * \pi}{100} j$ , {j, 1, 100}];
           [表格]

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

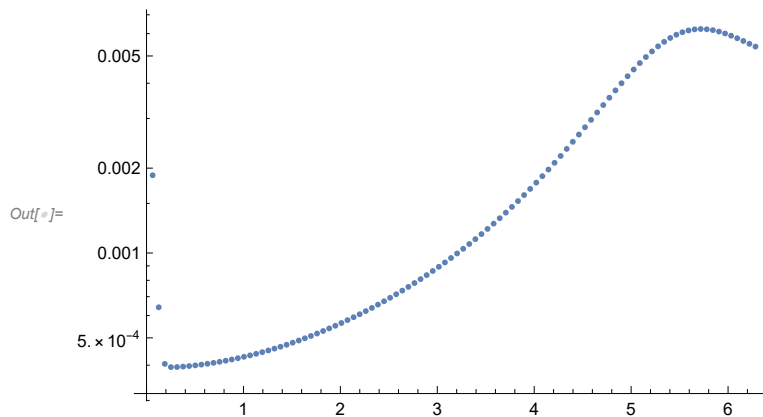
Do[
  [Do循环]
    Δt = ΔtList[[j]];
    {Hmat, Smat} = funMatRTE[Δ, Eg, Δt, d, probφ];
    {EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
    err = EK - Eg;
    εKList[[j]] = err;
    , {j, 1, Length[ΔtList]}]
           [长度]

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



```

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

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

```

Filter

```

In[ ]:=  $\tau$ MIN = 0;
 $\tau$ MAX = 64;
While[True,
  |While... |真
     $\tau$  = ( $\tau$ MIN +  $\tau$ MAX) / 2.;
    {Hmat, Smat} = funMatF[ $\Delta$ , Eg, 0,  $\tau$ , 1, prob $\phi$ ];
    EK = Hmat[[1, 1]] / Smat[[1, 1]];
    err = EK - Eg;
    If[err >  $\epsilon$ B,  $\tau$ MIN =  $\tau$ ];
    |如果
    If[err <  $\epsilon$ B,  $\tau$ MAX =  $\tau$ ];
    |如果
    (*Print[{err,  $\tau$ MIN,  $\tau$ MAX}];*)
    |打印
    If[Abs[err -  $\epsilon$ B] < 10-10, Break[]];
    |... |绝对值 |跳出循环
  ];
 $\tau$ 

```

Out[]:= 11.2447

```

In[ ]:= ΔEList = Table[ $\frac{2.}{d * 100} * j$ , {j, 1, 100}];
           [表格]

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

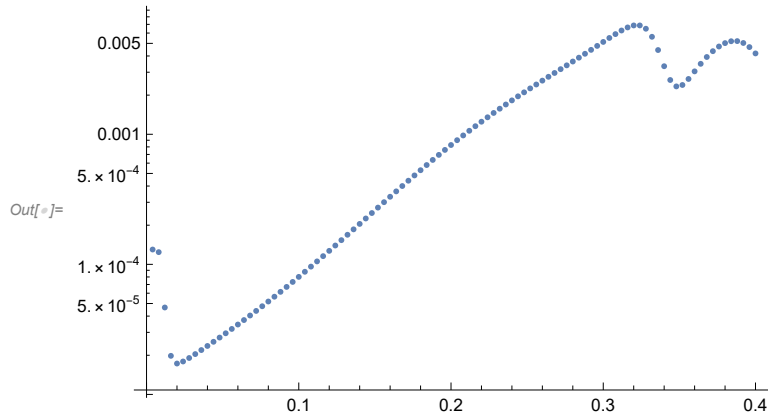
Do[ (
  [Do循环]
    ΔE = ΔEList[[j]];
    {Hmat, Smat} = funMatF[Δ, Eg, ΔE, τ, d, probφ];
    {EK, cn} = funSubDiag[Hmat + η * Id, Smat + η * Id];
    err = EK - Eg;
    εKList[[j]] = err;
  ), {j, 1, Length[ΔEList]}]
           [长度]

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



```

In[ ]:= E0 = Eg;
        {Hmat, Smat} = funMatF[Δ, 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 = {{104, 1020}, {10-6, 100}};
Fig1 = ListLogLogPlot[
  点集的双对数图

  {Transpose[{MList, 0. * MList + 1. * eK}], Transpose[{MList, 0. * MList + 2. * eK}]},
  转置 转置

  Transpose[{MList, ePListκ}], Transpose[{MList, eCPLISTκ}],
  转置 转置

  Transpose[{MList, eGPLISTκ}], Transpose[{MList, eIPLISTκ}],
  转置 转置

  Transpose[{MList, eITELISTκ}], Transpose[{MList, eRTELISTκ}],
  转置 转置

  Transpose[{MList, eFLISTκ}]]], PlotRange → PR, Joined → True,
  转置 绘制范围 连接点 真

  PlotStyle → {{Thickness[0.004], Cyan}, {Thickness[0.004], Brown}, {Thickness[0.004],
  绘图样式 粗细 蓝绿色 粗细 棕色 粗细
    Red, Dashed}, {Thickness[0.004], Yellow, Dashed}, {Thickness[0.004], Blue, Dashed},
    红色 虚线 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,
  标签样式 字体大小 字体系列 图像尺寸

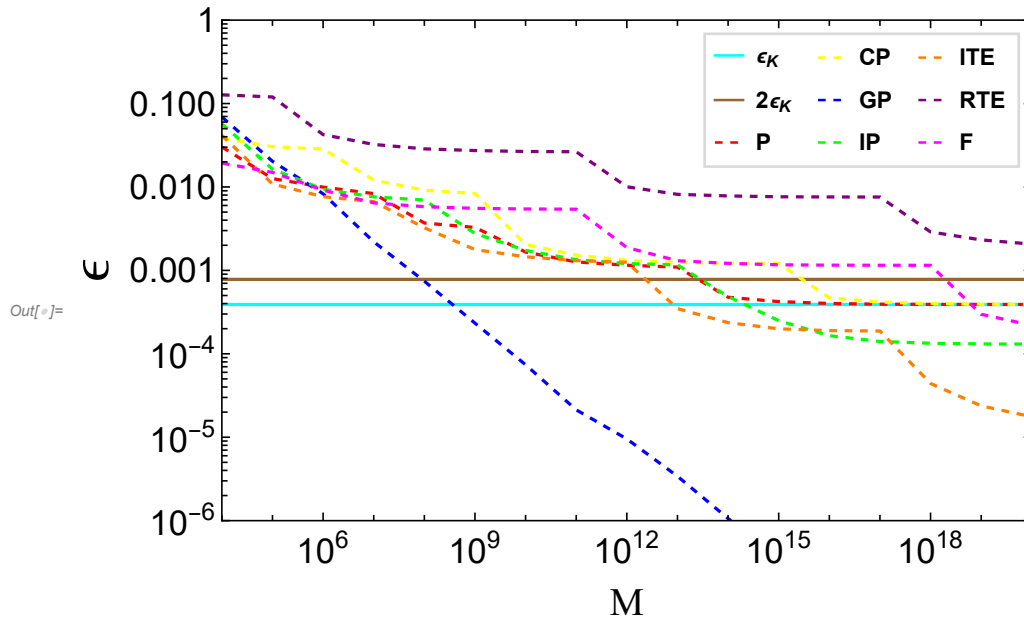
  PlotLegends → Placed[LineLegend[{"εκ", "2εκ", "P", "CP", "GP", "IP", "ITE", "RTE", "F"}],
  绘图的图例 放置 线的图例

    LegendFunction → (Framed[#, FrameStyle → LightGray] &), LegendMarkerSize → {16, 8},
    图例函数 加边框 边框样式 浅灰色 图例标记尺寸

    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

```

```

In[ ]:= l1leg1 = LineLegend[{Cyan}, {" $\epsilon_K$ "}, LegendMarkerSize → {14, 7},
|线的图例 |蓝绿色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
l1leg2 = LineLegend[{Brown}, {" $2\epsilon_K$ "}, LegendMarkerSize → {14, 7},
|线的图例 |棕色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg1 = PointLegend[{Red}, {"P"}, LegendMarkerSize → {14, 7},
|点的图例 |红色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg2 = PointLegend[{Yellow}, {"CP"}, LegendMarkerSize → {14, 7},
|点的图例 |黄色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg3 = PointLegend[{Blue}, {"GP"}, LegendMarkerSize → {14, 7},
|点的图例 |蓝色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg4 = PointLegend[{Green}, {"IP"}, LegendMarkerSize → {14, 7},
|点的图例 |绿色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg5 = PointLegend[{Orange}, {"ITE"}, LegendMarkerSize → {14, 7},
|点的图例 |橙色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg6 = PointLegend[{Purple}, {"RTE"}, LegendMarkerSize → {14, 7},
|点的图例 |紫色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];
p1leg7 = PointLegend[{Magenta}, {"F"}, LegendMarkerSize → {14, 7},
|点的图例 |品红色 |图例标记尺寸
|标签样式 |黑色 |粗体 |字体大小 |字体系列 |图例边幅
LabelStyle → {Black, Bold, FontSize → 12, FontFamily → "Arial"}, LegendMargins → 0];

```

Fig2 =

```

Legended[Show[Table[ListLogLogPlot[{Transpose[{MList, 0. * MList + 1. *  $\epsilon_K$ }],
图例 显示 表格 点集的双对数图 转置

Transpose[{MList, 0. * MList + 2. *  $\epsilon_K$ }], Transpose[{MList,  $\epsilon_{PList}[i]$ }],
转置 转置

Transpose[{MList,  $\epsilon_{CPList}[i]$ }], Transpose[{MList,  $\epsilon_{GPList}[i]$ }],
转置 转置

Transpose[{MList,  $\epsilon_{IPList}[i]$ }], Transpose[{MList,  $\epsilon_{ITEList}[i]$ }],
转置 转置

Transpose[{MList,  $\epsilon_{RTEList}[i]$ }], Transpose[{MList,  $\epsilon_{FList}[i]$ }], 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", " $\epsilon$ "},
指令 黑色 粗细 边框标签

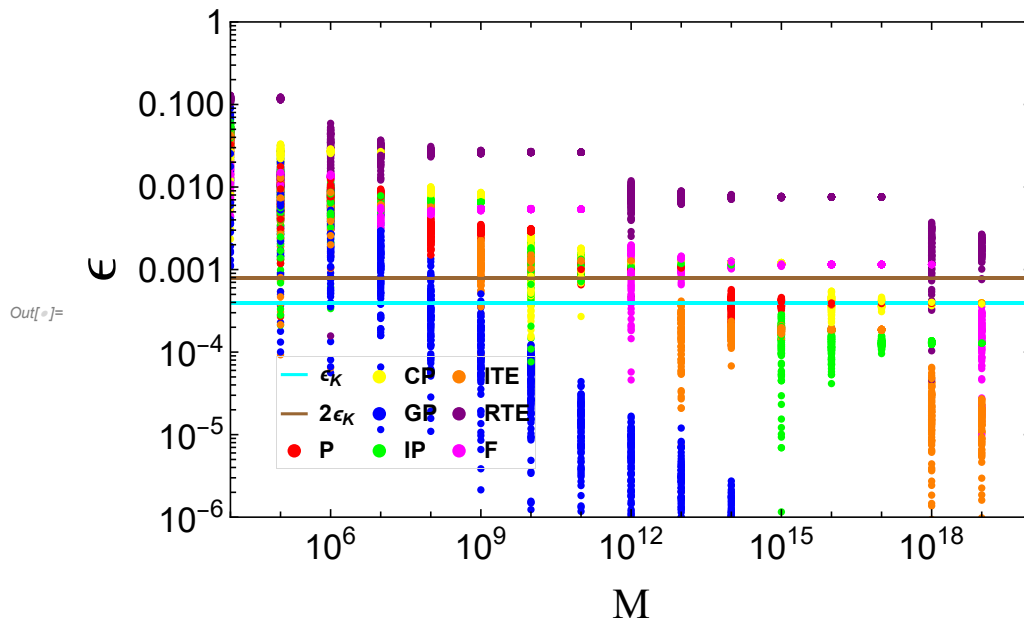
LabelStyle → {FontSize → 22, FontFamily → "Arial"}, ImageSize → 500, PlotStyle →
标签样式 字体大小 字体系列 图像尺寸 绘图样式

{Cyan, Brown, Red, Yellow, Blue, Green, Orange, Purple, Magenta}], {i, 1, rep}]],

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}}]]

```



```

In[ ]:= Export["C:\\Users\\John\\Desktop\\Revise\\Thresholding comparison th=10.pdf", Fig1];
导出 常量

```