Test

Model with a middle defect and a small defect on site 1
Anisotropic, open boundaries

$\sum_{n=1}^{L-1} \frac{J}{4} (\sigma_n^x \sigma_{n+1}^x + \sigma_n^y \sigma_{n+1}^y + 0.48 \sigma_n^z \sigma_{n+1}^z) + 0.9 \frac{J}{2} \sigma_{L/2}^z + 0.1 \frac{J}{2} \sigma_1^z$

Directory

Eigenvalues

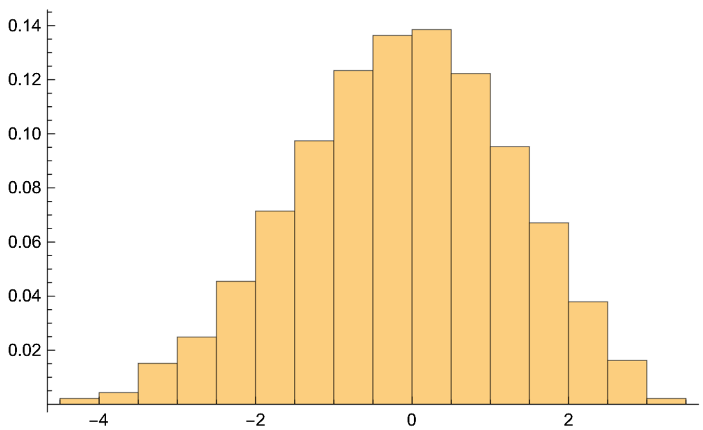
Histogram of the EIGENVALUES

In[∘]:=

```
te = Import["Eig_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
ta = Table[te[[k, 1]], {k, 1, Length[te]}];
dim = Length[ta];

Print["NORMALIZED Histogram. It has a Gaussian shape, but not symmetric."]
Histogram[ta, Automatic, "Probability"]
```

```
NORMALIZED Histogram. It has a Gaussian shape, but not symmetric.
```

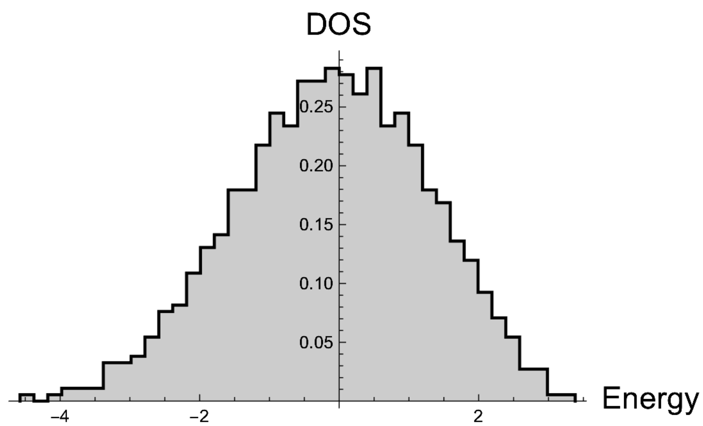
Out[∘]=



DOS

In[∘]:=
```
te = Import["DOS_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
dim = 1000.;
ListPlot[te, Joined → True, PlotStyle → Black,
 Filling → Axis, AxesLabel → {"Energy", "DOS"}]
```

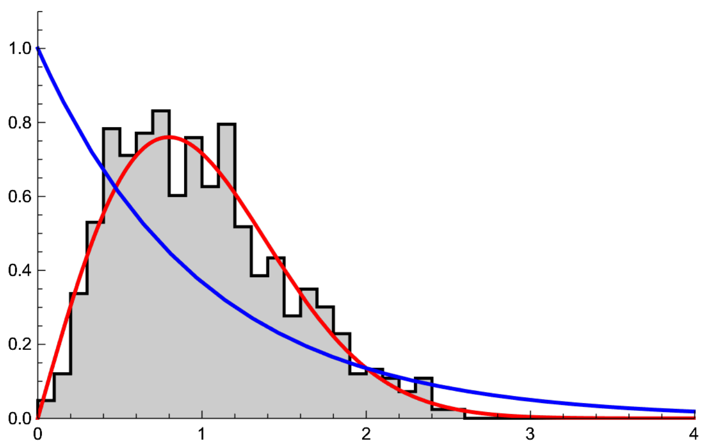
Out[∘]=



Level spacing distribution: P(s)

In[∘]:=
```
(* Theoretical curves *)
Clear[WignerDyson, Poisson];
WignerDyson = Plot[Pi s / 2. Exp[-Pi s^2 / 4.],
   {s, 0, 8}, PlotRange → {0, 1}, PlotStyle → {Red, Thick},
   LabelStyle → Directive[Black, Bold, Medium], AxesLabel → {"s", "P"}];
Poisson = Plot[Exp[-s], {s, 0, 8}, PlotRange → {0, 1}, PlotStyle → {Blue, Thick},
   LabelStyle → Directive[Black, Bold, Medium], AxesLabel → {"s", "P"}];

(* Numerical results *)
te = Import["Ps_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
dim = 1000.;
aa = ListPlot[te, Joined → True,
   PlotStyle → Black, Filling → Axis, PlotRange → {{0, 4}, {0, 1.1}}];

Show[{aa, WignerDyson, Poisson}]
```

Out[∘]=



Average of the ratio of consecutive levels: $\tilde{r}$

In[∘]:=
```
te = Import["rTilde_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
Print["The numerical result r̃=", te⟦1, 1⟧, " is close to theoretical r̃=0.54"]
```

```
The numerical result r̃=0.534665 is close to theoretical r̃=0.54
```

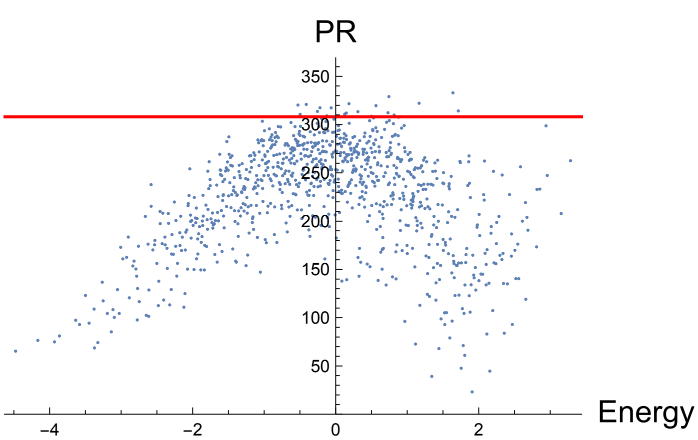
Eigenstates

PR and Shannon

In[∘]:=
```
te = Import["PRSh_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
pr = Table[{te[[k, 1]], te[[k, 2]]}, {k, 1, Length[te]}];
sh = Table[{te[[k, 1]], te[[k, 3]]}, {k, 1, Length[te]}];

dim = Length[te];
prplot = ListPlot[pr, PlotRange → {0, dim / 2.5}, AxesLabel → {"Energy", "PR"}];
shplot =
  ListPlot[sh, PlotRange → {0, Log[2 dim]}, AxesLabel → {"Energy", "Shannon"}];
prgoe = Plot[dim / 3., {x, -100, 100}, PlotStyle → Red];
shgoe = Plot[Log[0.48 dim], {x, -100, 100}, PlotStyle → Red];

Print[];
Print["Participation Ratio"];
Show[{prplot, prgoe}]
Print[];
Print["Shannon Entropy"];
Show[{shplot, shgoe}]
```

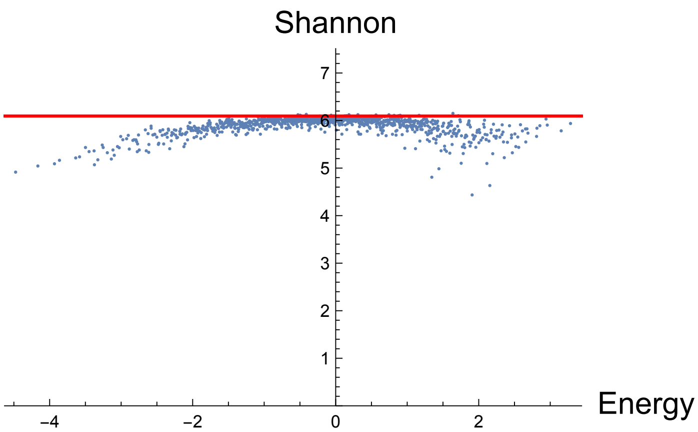
Participation Ratio

Out[∘]=



Shannon Entropy

Out[ ]=



ETH: mid-defect (chaos) vs clean XXZ (integrable)

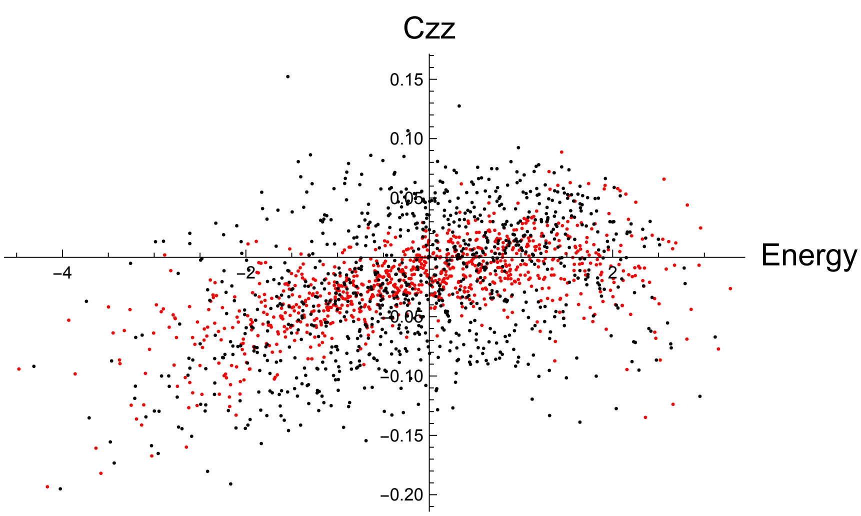
EEV: diagonal-ETH

Czz = $\langle \alpha | S^z_{L/2} \, S^z_{L/2+1} | \alpha \rangle$

In[ ]:=

```
te = Import["EEV_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
ta = Import["EEV_L12u06Jz0.48dF0.00lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
ListPlot[{te, ta}, PlotStyle → {Red, Black}, AxesLabel → {"Energy", "Czz"}]
```

Out[ ]=

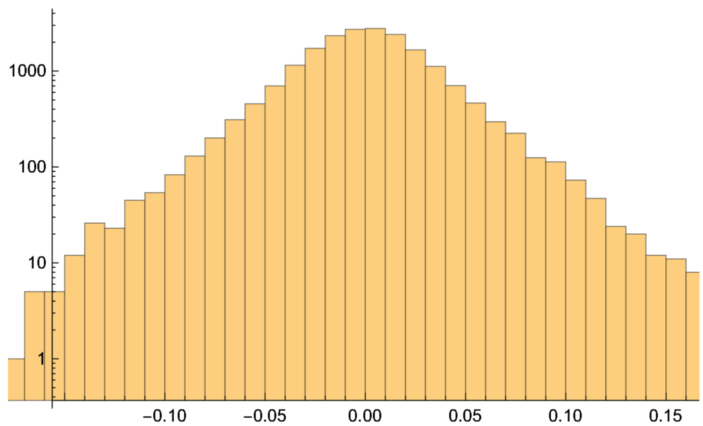


OFF-diagonal-ETH: 200 eigenstates in the middle of the spectrum
Oab= $\langle\beta\,|S^z_{L/2}|\alpha\rangle$

In[∘]:=
```
te = Import["Oab_L14u07Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
teF = Flatten[te];
ta = Import["Oab_L14u07Jz0.48dF0.00lF0.00hF0.00bF0.10AveR0001.dat", "Table"];
taF = Flatten[ta];
Print["Oab for the chaotic model"];
Histogram[teF, ScalingFunctions → {"Linear", "Log"},
 PlotRange → {{-0.15, 0.16}, All}]
Print[];
Print["Oab for the integrable model"];
Histogram[taF, ScalingFunctions → {"Linear", "Log"},
 PlotRange → {{-0.15, 0.17}, All}]
```

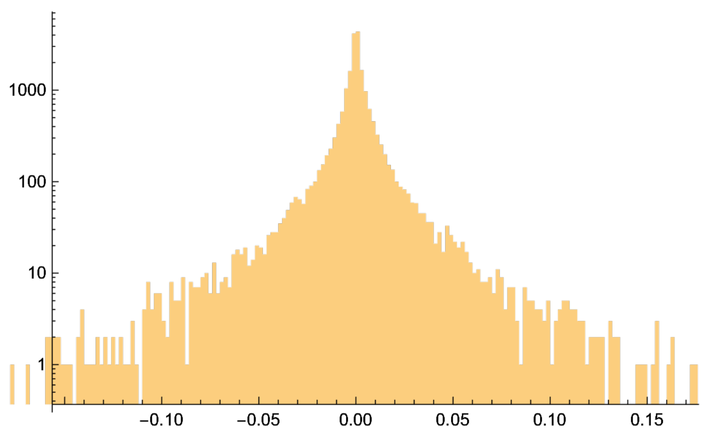
```
Oab for the chaotic model
```

Out[∘]=




```
Oab for the integrable model
```

Out[∘]=



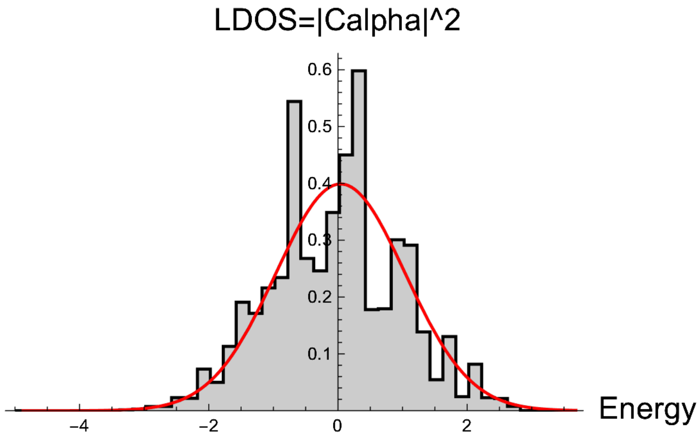
Dynamics

LDOS

In[∘]:=
```
ena = Import["Calpha_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001AveI0100.dat"];
dim = Length[ena];
Energies = Table[ena⟦k, 1⟧, {k, 1, dim}];
Calpha = Table[ena⟦k, 2⟧, {k, 1, dim}];

ta = Import[
   "InfoIni_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001AveI0100.dat", "Table"];
gamSq = ta⟦11, 1⟧;
Emid = ta⟦5, 1⟧;


Clear[lbin, tot, minE, maxE, Eint, Em];
lbin = 0.2;
Min[Energies];
Max[Energies];
minE = Min[Energies] - 2 lbin;
maxE = Max[Energies] + 2 lbin;
tot = (maxE - minE) / lbin + 1;
Eint = Table[(minE - lbin / 2.) + lbin (k - 1), {k, 1, tot + 1}];
Em = Table[ minE + lbin (k - 1), {k, 1, tot}];

Clear[ldos];
Do[
  ldos[k] = 0.;
  , {k, 1, tot + 10}];

Do[
  Do[
    If[Eint⟦k⟧ ≤ Energies⟦j⟧ < Eint⟦k + 1⟧, ldos[k] = ldos[k] + Calpha⟦j⟧ ^2 ];
    , {k, 1, tot}];
  , {j, 1, dim}];

ldosLista = Flatten[Table[
     {{Eint⟦k⟧, ldos[k] / (lbin )}, {Eint⟦k + 1⟧, ldos[k] / (lbin )}}, {k, 1, tot}], 1];

ldosPlot = ListPlot[ldosLista, Joined → True, PlotStyle → Black, Filling → Axis,
   AxesLabel → {"Energy", "LDOS=|Calpha|^2"}, PlotRange → {All, {0, All}}];
bb = Plot[(1. / Sqrt[2. Pi gamSq ]) Exp[-0.5 ((x - Emid) ^2) / gamSq],
   {x, minE, maxE}, PlotRange → All, PlotStyle → Red];
Print[]
Print[]
Print["The LDOS is naturally"]
Show[{ldosPlot, bb}]
```

The LDOS is naturally

Out[ ]=



SP

```
In[•]:= totIni = 100;
ta =
  Import["SP_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001AveI0100.dat", "Table"];
splot = ListLogLogPlot[ta, Joined → True, PlotRange → All,
   AxesLabel → {"TIME", "SP"}, PlotLegends → {"numerics"}];
te = Import["InfoIni_L12u06Jz0.48dF0.90lF0.00hF0.00bF0.10AveR0001AveI0100.dat",
   "Table"];

ipr0 = Sum[te⟦14 + 18 (k - 1), 1⟧, {k, 1, totIni}] / totIni;
ipr0plot =
  LogLogPlot[ipr0, {x, 0.001, 200 000}, PlotStyle → Red, PlotLegends → {"IPRo"}];

gauSq = Sum[te⟦11 + 18 (k - 1), 1⟧, {k, 1, totIni}] / totIni;
gaus = LogLogPlot[Exp[-gauSq x^2], {x, 0.001, 20},
   PlotStyle → Darker[Green], PlotLegends → {"Gauss"}];

Show[{splot, ipr0plot, gaus}]
```

Out[•]=