Average IPR vs Jz

- Description

  The Inverse Participation Ratio (IPR) of each eigenstate measures how much spread it is in a particular basis. A high value of IPR means that the eigenstate is spread out in that basis, while a low value of IPR means that the state is more localized. Here we choose the site-basis and compute the average value of the IPR's of all eigenstates for each value of Jz. (The code provided here is used to obtain the bottom of Figure 1 in the paper)

- Notation

  *) IPR = Inverse Participation Ratio

  *) AveIPR = average value of IPR for all eigenstates

- Code for IPR vs Jz

```
(*Parameters of the Hamiltonian*)
Clear[chainsize, upspins, downspins, dim, Jxy, Jz, open];
chainsize = 10;
upspins = chainsize / 2;
downspins = chainsize - upspins;
dim = chainsize! / (upspins! downspins!);
Jxy = 1.0;
Jz = 5;
open = 1;
(*Creating the basis*)
Clear[onebasisvector, basis];
onebasisvector =
  Flatten[{Table[1, {k, 1, upspins}], Table[0, {k, 1, downspins}]}];
basis = Permutations[onebasisvector];

(*ELEMENTS OF THE HAMILTONIAN*)
(*Initialization*)
Clear[HH];
Do[Do[HH[i, j] = 0., {j, 1, dim}], {i, 1, dim}];

(*Diagonal elements-Ising interaction*)
Do[
  Do[
    HH[i, i] = HH[i, i] + (Jz / 4.) * (-1.)^(basis[[i, k]] + basis[[i, k + 1]]);
   , {k, 1, chainsize - 1}];
, {i, 1, dim}];
(*Term included in the Ising interaction if the chain is closed*)
If[open == 0,
  Do[HH[i, i] = HH[i, i] + (Jz / 4.) * (-1.)^(basis[[i, chainsize]] + basis[[i, 1]]),
   {i, 1, dim}]];
```

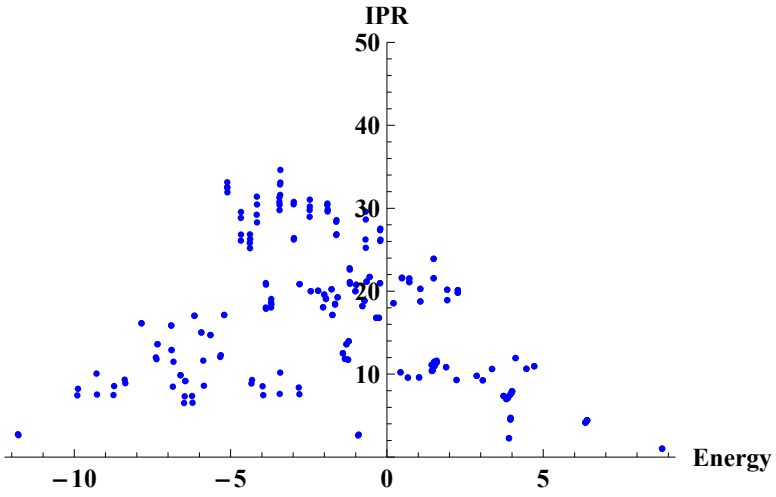
```
(*Off-diagonal elements-flip-flop term*)
Clear[howmany, site];
Do[
  Do[
    (*Initialization*)
howmany = 0
Do[site[z] = 0, {z, 1, chainsize}];
(*Sites where states i and j differ*)
Do[If[basis[[i, k]] ≠ basis[[j, k]], {howmany = howmany + 1, site[howmany] = k}];,
     {k, 1, chainsize}];
(*Coupling matrix element-when only two neighbor sites differ*)
If[howmany == 2, If[site[2] - site[1] == 1,
      {HH[i, j] = HH[i, j] + Jxy / 2., HH[j, i] = HH[j, i] + Jxy / 2.}]];
(*Additional term for closed system*)If[open == 0, If[site[2] - site[1] ==
       chainsize - 1, {HH[i, j] = HH[i, j] + Jxy / 2., HH[j, i] = HH[j, i] + Jxy / 2.}]];
, {j, i + 1, dim}];
, {i, 1, dim - 1}];

(* TOTAL HAMILTONIAN AND DIAGONALIZATION *)
Clear[Hamiltonian, Energy, Vector];
Hamiltonian = Table[Table[HH[i, j], {j, 1, dim}], {i, dim}];
Energy = Eigenvalues[Hamiltonian];
Vector = Eigenvectors[Hamiltonian];

(*Inverse Participation Ratio:IPR*)

Clear[IPR];
Do[
  IPR[i] = 1 / Sum[Vector[[i, k]]^4, {k, 1, dim}];
, {i, 1, dim}];

(*Plot:IPR vs Jz*)
Clear[tab];
tab = Table[{Energy[[j]], IPR[j]}, {j, 1, dim}];
ListPlot[tab, LabelStyle → Directive[Black, Bold, Medium],
 PlotStyle → Blue, AxesLabel → {"Energy", "IPR"}, PlotRange → {0, 50}]
```


IPR
50
40
30
20
10
−10
−5
0
5
Energy