

Dynamic

- Description

We study the time evolution of the system for a particular initial state corresponding to one of the basis vectors.

We plot the magnetization of each site, with a magnetization of 0.5 corresponding to an upspin, and a magnetization

of -0.5 corresponding to a downspin.

We also plot the probability of finding each of the basis vectors is time.

(The code provided here is used to obtain Figure 2 in the paper).

- Parameters explained

*) initialstate = initial state corresponding to one of the site-basis vectors

*) endtime = how many times the loop for time is repeated (choice depends on the system)

*) increment = dt = discrete interval of time (choice depends on the system)

*) Psi[t] = evolved state

*) Magsite = magnetization of each site

- Code for the Dynamics

- Hamiltonian, eigenvalues and eigenstates

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(*Parameters of the Hamiltonian*)
Clear[chainsize, upspins, downspins, dim, Jxy, Jz, open];
chainsize = 4;
upspins = 2;
downspins = chainsize - upspins;
dim = chainsize! / (upspins! downspins!);
Jxy = 1.0;
Jz = 10;
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[
```

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      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];

  (*Choose an initial state*)
  Do[
    If[basis[[i, 1]] == 1 && basis[[i, 3]] == 1, initialstate = i];
    , {i, 1, dim}];

  (*DYNAMICS*)
  Clear[endtime, PSI, increment, Magsite];
  endtime = 81;
  increment = 0.5;
  Do[PSI[t] = Sum[Vector[[j, initialstate]]
    Vector[[j]] Exp[-I Energy[[j]] (t - 1) increment], {j, 1, dim}];
  (*Magnetization*)
  Do[Magsite[j, t] = 0.5 Sum[Abs[PSI[t] [[i]]]^2 (-1.) ^ (1 + basis[[i, j]]), {i, dim}];
    , {j, 1, chainsize}];
  (*Print[{(t-1)increment, Magsite[1, t]}];*)

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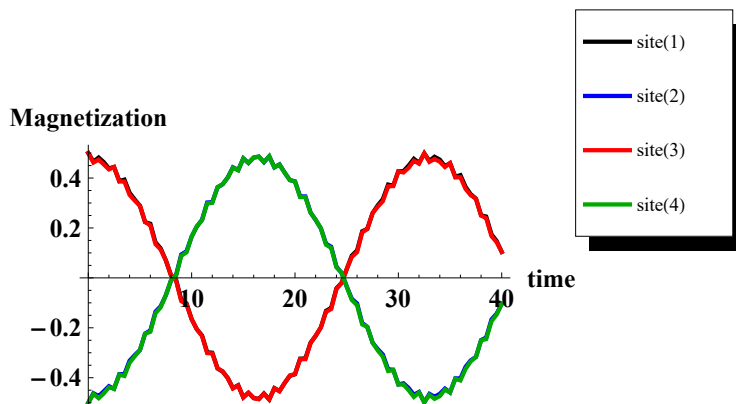
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, {t, 1, endtime}];

(*Call Package for Legends*)
<<PlotLegends`
Clear[magT, ProbT];
Do[magT[j] = Table[{(t - 1) increment, Magsite[j, t]}, {t, 1, endtime}],
  {j, 1, chainsize}];
Do[ProbT[k] = Table[{(t - 1) increment, Abs[PSI[t][[k]]]^2}, {t, 1, endtime}],
  {k, 1, dim}];

Print[];
Print["Magnetization of each site"];
ListPlot[Table[magT[j], {j, 1, chainsize}], PlotRange → All, Joined → True,
  PlotStyle → {{Thick, Black}, {Thick, Blue}, {Thick, Red}, {Thick, Darker[Green]}},
  LabelStyle → Directive[Black, Bold, Medium],
  PlotLegend → Table["site"[x], {x, 1, dim}],
  LegendPosition → {1, 0}, AxesLabel → {"time", "Magnetization"}]

Print[];
Print["Probability of each site-basis"];
ListPlot[Table[ProbT[k], {k, 1, dim}], PlotRange → All, Joined → True,
  PlotStyle → {{Thick, Black}, {Thick, Blue}, {Thick, Red}, {Thick, Darker[Green]},
    {Thick, Magenta}, {Thick, Brown}}, LabelStyle → Directive[Black, Bold, Medium],
  PlotLegend → Table[basis[[k]], {k, 1, dim}], LegendPosition → {1, 0},
  LegendSize → {1, 1}, AxesLabel → {"time", "Probability"},
  Frame → True, FrameLabel → {"Probability", ""}, {"Jt", "Δ=10"}]
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Magnetization of each site



Probability of each site-basis

