

Hopping only

```
In[398]:= H[Nl_] := Table[If[Abs[i - j] == 1, -1, 0], {i, 1, Nl}, {j, 1, Nl}];
H[10] // MatrixForm
```

```
Out[399]//MatrixForm=

$$\begin{pmatrix} 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 0 \end{pmatrix}$$

```

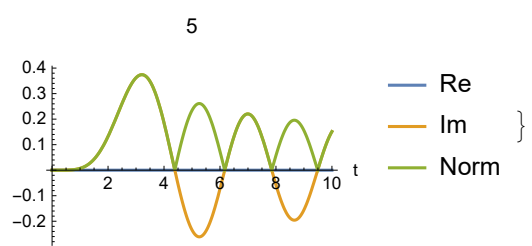
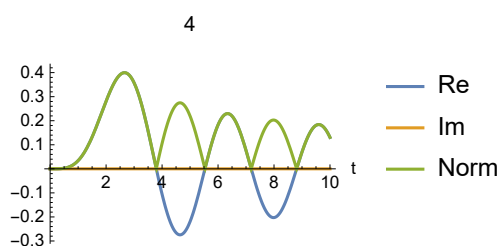
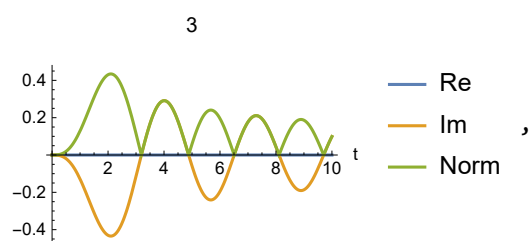
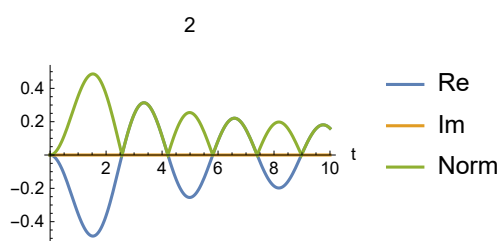
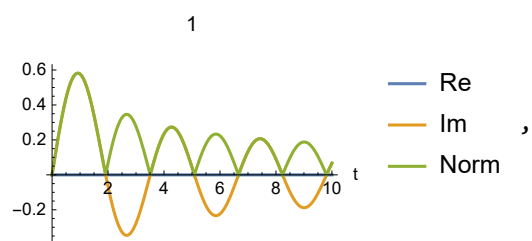
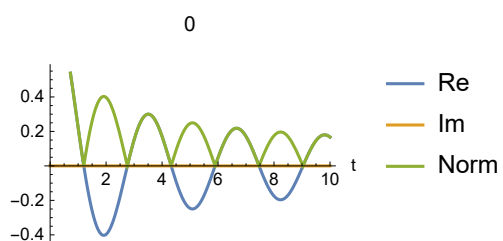
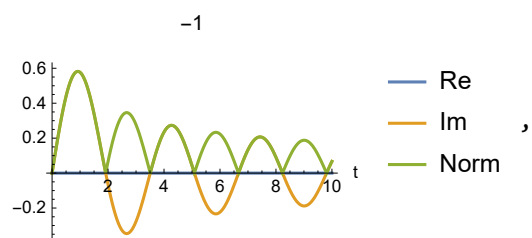
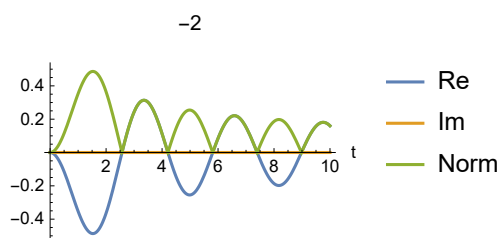
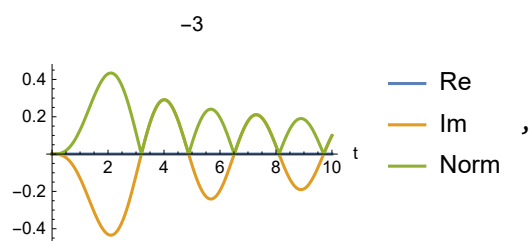
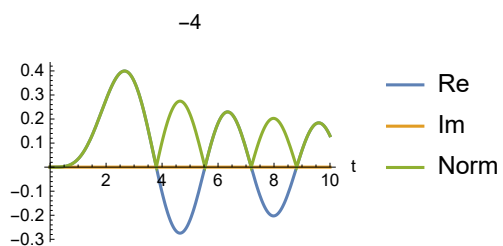
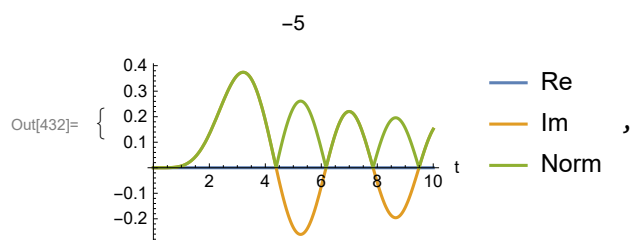
```
In[ ]:= (*{EVals,EVecs}=Eigensystem[N[H[100]]];
sortedEVecs=(EVecs)[[Ordering[EVals]]];
sortedEVals=Sort[EVals];
ListPlot[sortedEVals]

{ListPlot[sortedEVecs[[1]]],ListPlot[sortedEVecs[[2]]],
ListPlot[sortedEVecs[[3]]],ListPlot[sortedEVecs[[98]]],
ListPlot[sortedEVecs[[99]]],ListPlot[sortedEVecs[[100]]]}

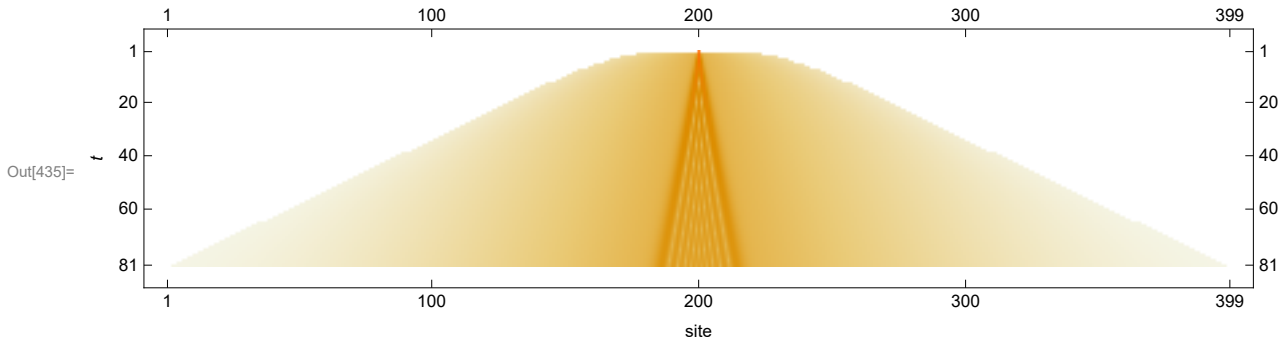
{ListLinePlot[
RotateRight[Abs[Fourier[sortedEVecs[[1]]]],50],PlotRange->All,Frame->True],
ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[2]]]],50],PlotRange->All,
Frame->True],ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[3]]]],50],
PlotRange->All,Frame->True],ListLinePlot[
RotateRight[Abs[Fourier[sortedEVecs[[100]]]],50],PlotRange->All,Frame->True]}*)
```

```
In[424]:= ClearAll@ψ;
H[Nl_] := Table[If[Abs[i - j] == 1, -1, 0], {i, 1, Nl}, {j, 1, Nl}];
Nl = 400;
tf = 50;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == H[Nl].ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];
```

```
In[431]:= tmax = 10;
Table[Plot[{Re[ψ[t][[1, i]]], Im[ψ[t][[1, i]]], Norm[ψ[t][[1, i]]]},
{t, 0, tmax}, PlotLegends -> {"Re", "Im", "Norm"},
AxesLabel -> {"t", ""}, PlotLabel -> i - Nl/2], {i, Nl/2 - 5, Nl/2 + 5}]
(*Manipulate[ListLinePlot[Abs[ψ[t]]^2,PlotRange->{0,1},PlotLabel->t],{t,0,5}]*)
```



```
In[433]:= sitenum = 398;
tmax = 8;
MatrixPlot[Table[Abs[ψ[t][[1, i]]],
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],
  FrameLabel → {t, "site"}, ImageSize → Full]
```



With Trap

```
In[400]:= H[Nl_, ω_] :=
  Table[If[i == j, (i - Nl/2)² ω², If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
H[10, 0.5] // MatrixForm
```

Out[401]//MatrixForm=

$$\begin{pmatrix} 4. & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 2.25 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1. & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0.25 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0. & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0.25 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 1. & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 2.25 & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4. & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 6.25 \end{pmatrix}$$

```
In[ ]:= (*{EVals,EVecs}=Eigensystem[N[H[100,1]]];
sortedEVecs=(EVecs)[[Ordering[EVals]]];
sortedEVals=Sort[EVals];
ListPlot[sortedEVals]

{ListPlot[sortedEVecs[[1]],PlotRange→All],
 ListPlot[sortedEVecs[[2]],PlotRange→All],
 ListPlot[sortedEVecs[[3]],PlotRange→All],
 ListPlot[sortedEVecs[[99]],PlotRange→All],
 ListPlot[sortedEVecs[[100]],PlotRange→All]}

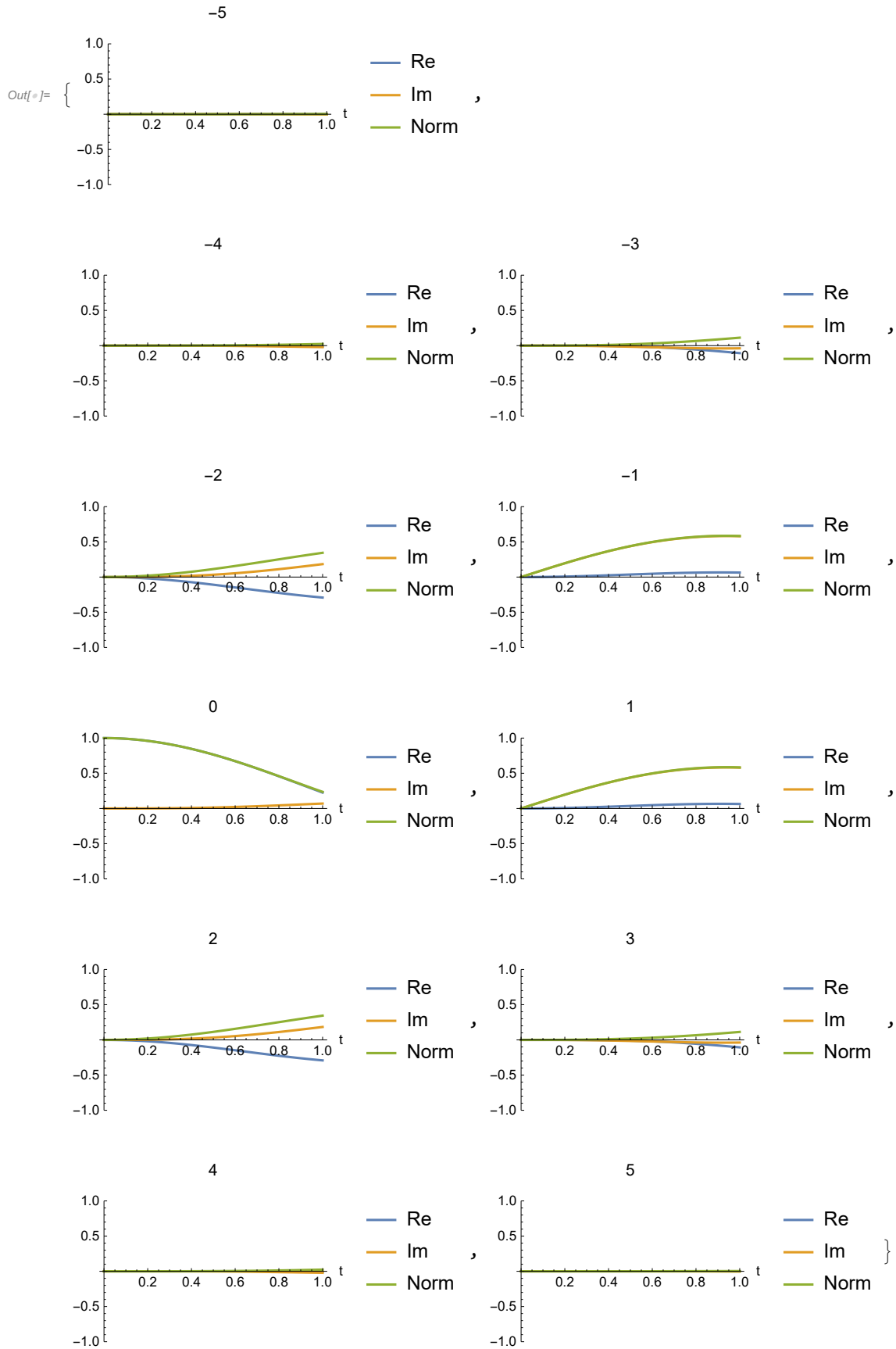
{ListLinePlot[
  RotateRight[Abs[Fourier[sortedEVecs[[1]]]],50],PlotRange→All,Frame→True],
 ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[2]]]],50],PlotRange→All,
  Frame→True],ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[3]]]],50],
  PlotRange→All,Frame→True],ListLinePlot[
  RotateRight[Abs[Fourier[sortedEVecs[[100]]]],50],PlotRange→All,Frame→True]}*)
```

Blue Detuned

```
ClearAll@ψ;
H[Nl_, ω_] :=
  Table[If[i == j, (i - Nl/2)2 ω2, If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
ω = 0.6;
Nl = 200;
tf = 8;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == H[Nl, ω].ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];
```

... NDSolve: Maximum number of 111926 steps reached at the point t == 6.929466769420081`.

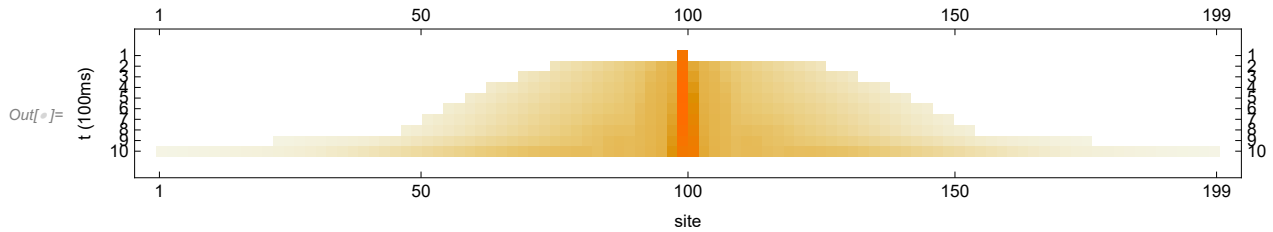
```
In[ ]:= tmax = 1;
Table[Plot[{Re[ψ[t][[1, i]]], Im[ψ[t][[1, i]]], Norm[ψ[t][[1, i]]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - Nl/2], {i, Nl/2 - 5, Nl/2 + 5}]
```



```

In[ ]:= sitenum = 198;
tmax = 0.9;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],
FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]

```



```

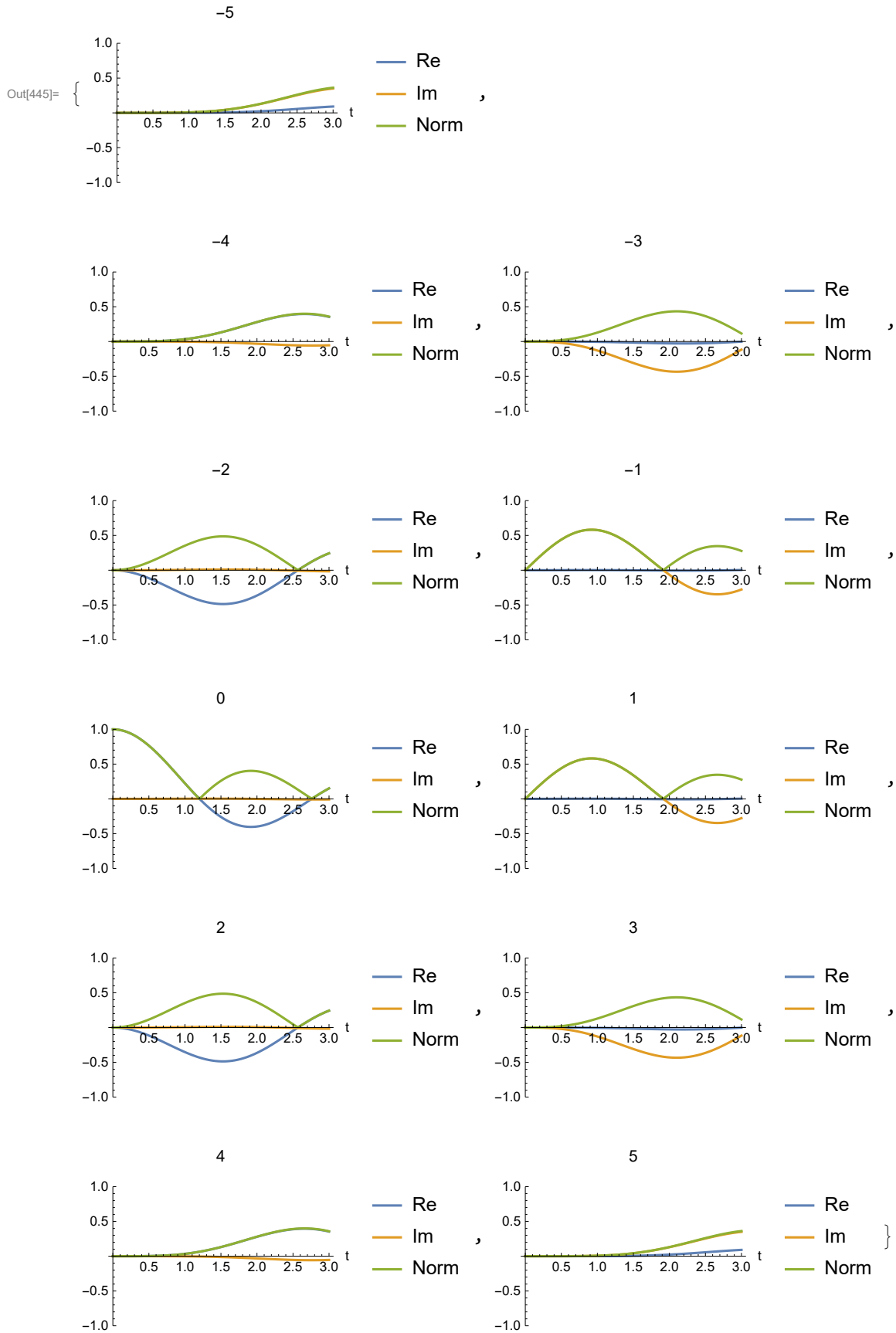
In[436]:= ClearAll@ψ;
H[Nl_, ω_] :=
  Table[If[i == j, (i - Nl/2)^2 ω^2, If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
ω = 0.1;
Nl = 200;
tf = 20;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == H[Nl, ω].ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

```

```

In[444]:= tmax = 3;
Table[Plot[{Re[ψ[t]][[1, i]], Im[ψ[t]][[1, i]], Norm[ψ[t]][[1, i]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - Nl/2], {i, Nl/2 - 5, Nl/2 + 5}]

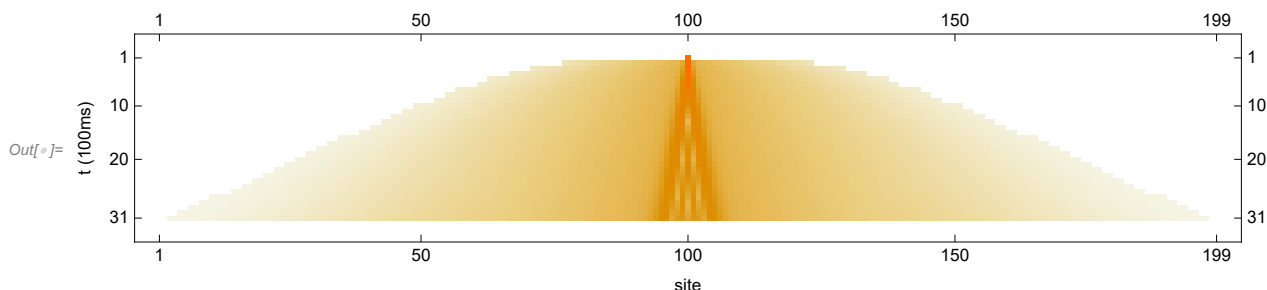
```



```
In[ ]:= sitenum = 198;
```

```
tmax = 3;
```

```
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],  
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],  
  FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]
```



Red Detuned

```
In[ ]:= ClearAll@ψ;
```

```
H[Nl_, ω_] :=
```

```
Table[If[i == j, -1 * (i - Nl/2)2 ω2, If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
```

```
ω = 0.6;
```

```
Nl = 200;
```

```
tf = 20;
```

```
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
```

```
s = NDSolve[{ID[ψ[t], t] == H[Nl, ω] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
```

```
ψ[t_] = Evaluate[ψ[t] /. s];
```

```
In[ ]:= (*λ[t_] := MatrixExp[I H[Nl] t] . ψ0;
```

```
Table[Plot[{Re[λ[t][[i]]], Im[λ[t][[i]]], Norm[λ[t][[i]]]}, {t, 0, tf},
```

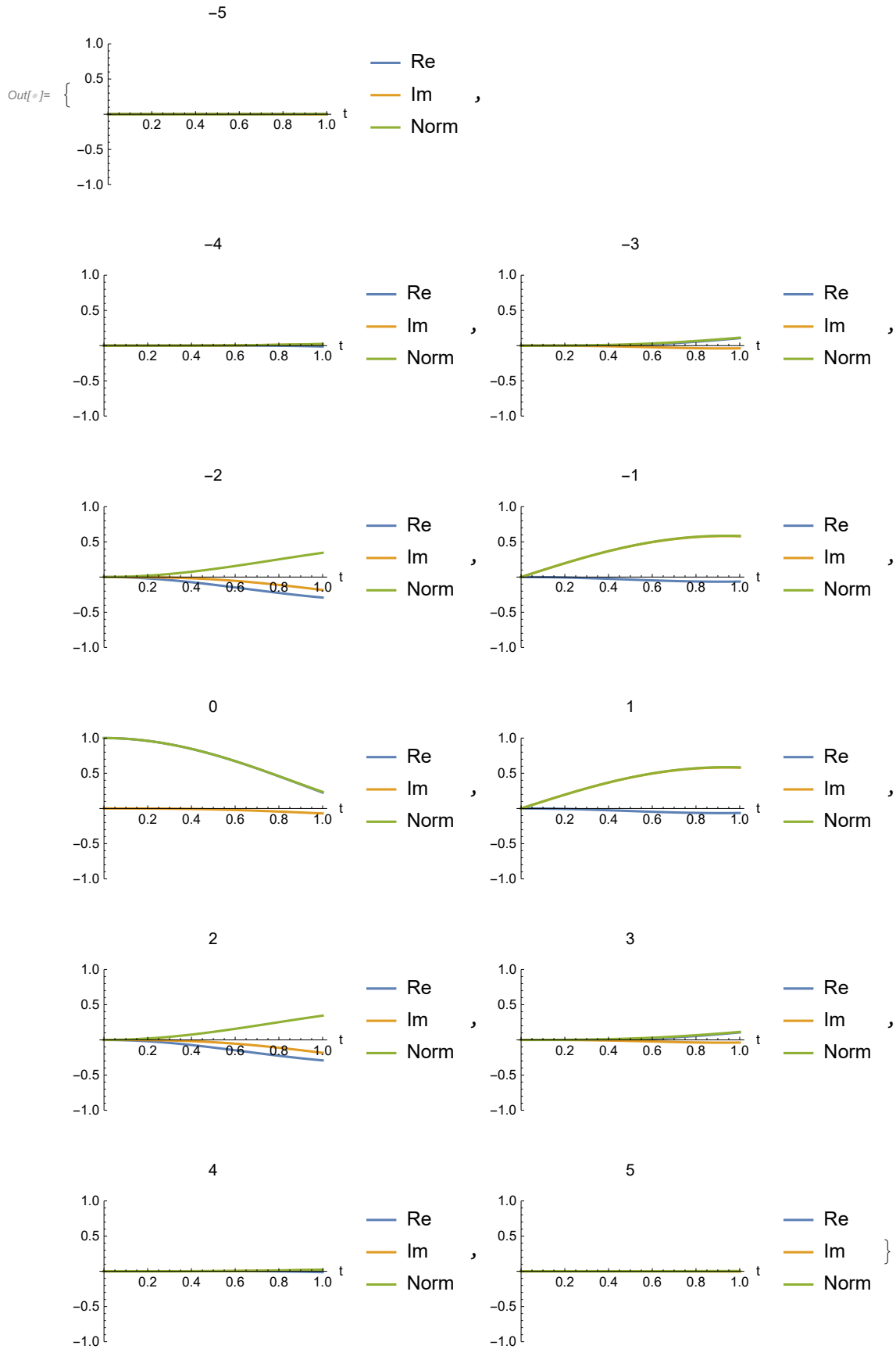
```
PlotLegends → {"Re", "Im", "Norm"}, AxesLabel → {"t", ""}, PlotLabel → i, {i, 1, Nl}]*)
```

```
In[ ]:= tmax = 1;
```

```
Table[Plot[{Re[ψ[t][[1, i]]], Im[ψ[t][[1, i]]], Norm[ψ[t][[1, i]]]},
```

```
{t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
```

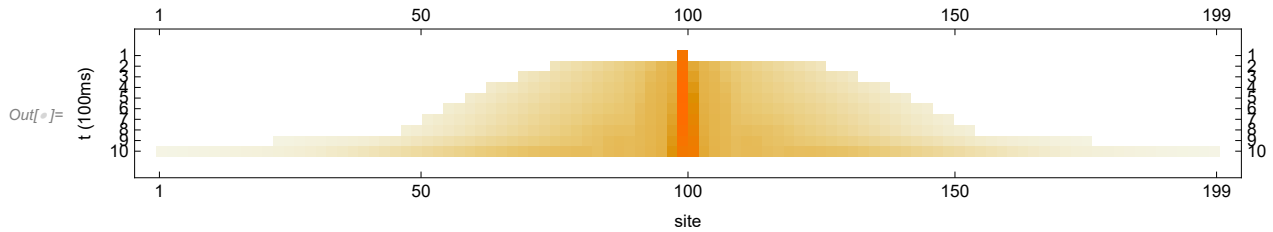
```
AxesLabel → {"t", ""}, PlotLabel → i - Nl/2, {i, Nl/2 - 5, Nl/2 + 5}]
```

```

In[456]:= sitenum = 198;
tmax = 0.9;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, N1/2 - sitenum/2, N1/2 + sitenum/2}],
FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]

```



```

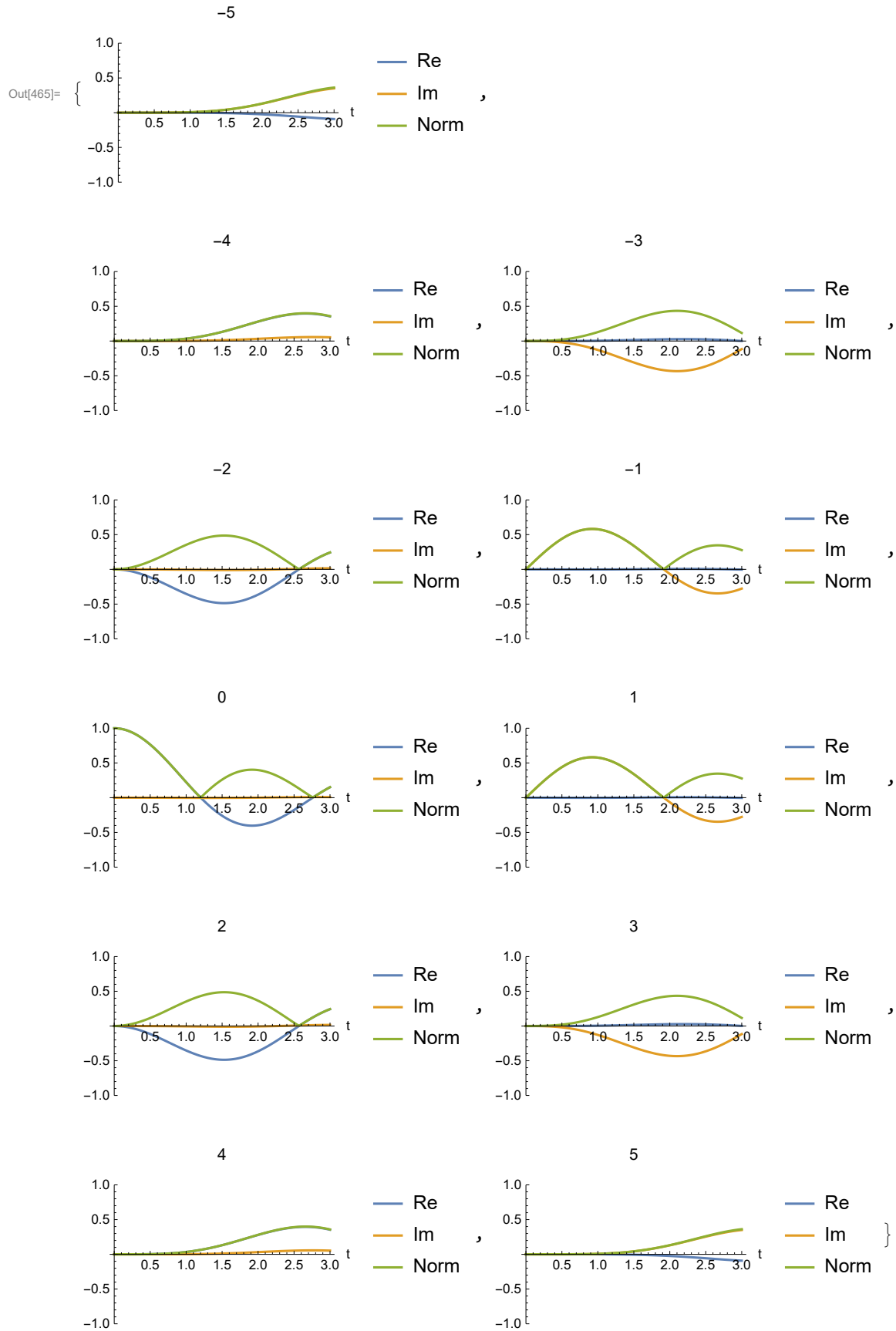
In[456]:= ClearAll@ψ;
H[N1_, ω_] :=
  Table[If[i == j, -1 * (i - N1/2)^2 ω^2, If[Abs[i - j] == 1, -1, 0]], {i, 1, N1}, {j, 1, N1}];
ω = 0.1;
N1 = 200;
tf = 20;
ψ0 = Table[If[i == N1/2, 1, 0], {i, 1, N1}];
s = NDSolve[{ID[ψ[t], t] == H[N1, ω].ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

```

```

In[464]:= tmax = 3;
Table[Plot[{Re[ψ[t]][[1, i]], Im[ψ[t]][[1, i]], Norm[ψ[t]][[1, i]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - N1/2], {i, N1/2 - 5, N1/2 + 5}]

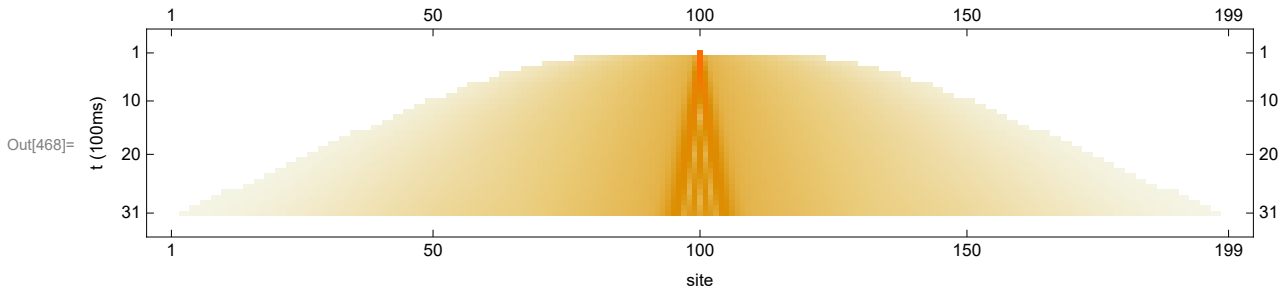
```



```
In[466]:= sitenum = 198;
```

```
tmax = 3;
```

```
MatrixPlot[Table[Abs[ψ[t][[1, i]]],  
  {t, 0, tmax, 0.1}, {i, N1/2 - sitenum/2, N1/2 + sitenum/2}],  
  FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]
```



With force term

```
In[408]:= H[N1_, F_] := Table[If[i == j, F * i, If[Abs[i - j] == 1, -1, 0]], {i, 1, N1}, {j, 1, N1}];  
H[10, 0.5] // MatrixForm
```

Out[409]//MatrixForm=

$$\begin{pmatrix} 0.5 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 1. & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1.5 & -1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 2. & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 2.5 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 3. & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 3.5 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4. & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 4.5 & -1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1 & 5. \end{pmatrix}$$

```
In[ ]:= (*{EVals,EVecs}=Eigensystem[N[H[100, 0.2]]];  
sortedEVecs=(EVecs)[[Ordering[EVals]]];  
sortedEVals=Sort[EVals];  
ListPlot[sortedEVals]
```

```
{ListPlot[sortedEVecs[[1]],PlotRange→All],  
ListPlot[sortedEVecs[[2]],PlotRange→All],  
ListPlot[sortedEVecs[[3]],PlotRange→All],  
ListPlot[sortedEVecs[[99]],PlotRange→All],  
ListPlot[sortedEVecs[[100]],PlotRange→All]}
```

```
{ListLinePlot[  
  RotateRight[Abs[Fourier[sortedEVecs[[1]]],50],PlotRange→All,Frame→True],  
ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[2]]],50],PlotRange→All,  
  Frame→True],ListLinePlot[RotateRight[Abs[Fourier[sortedEVecs[[3]]],50],  
  PlotRange→All,Frame→True],ListLinePlot[  
  RotateRight[Abs[Fourier[sortedEVecs[[100]]],50],PlotRange→All,Frame→True]}*)
```

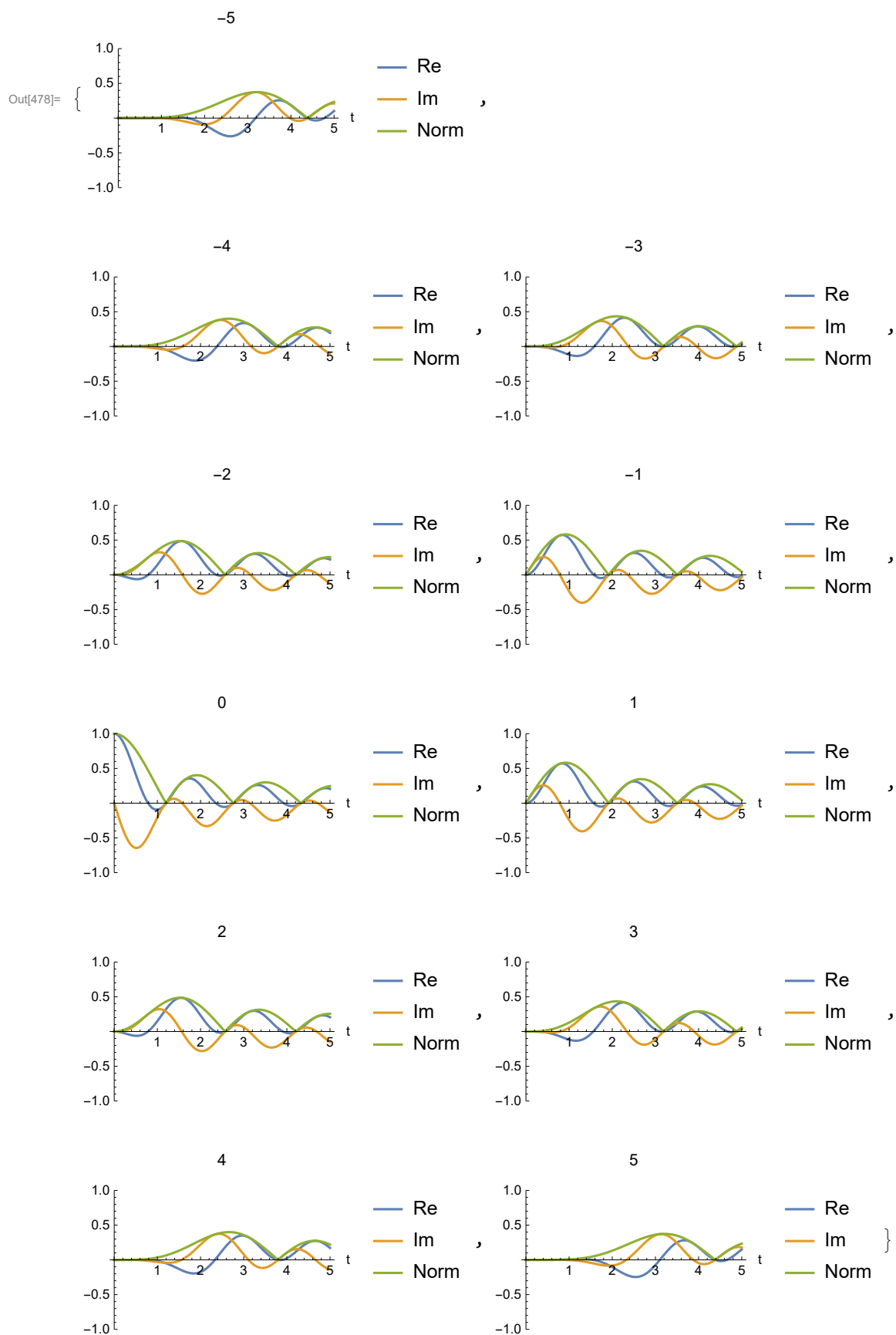
Small Force

```

In[469]:= ClearAll@ψ;
H[Nl_, F_] := Table[If[i == j, F * i, If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
Nl = 400;
tf = 10;
F = 0.01;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == H[Nl, F] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

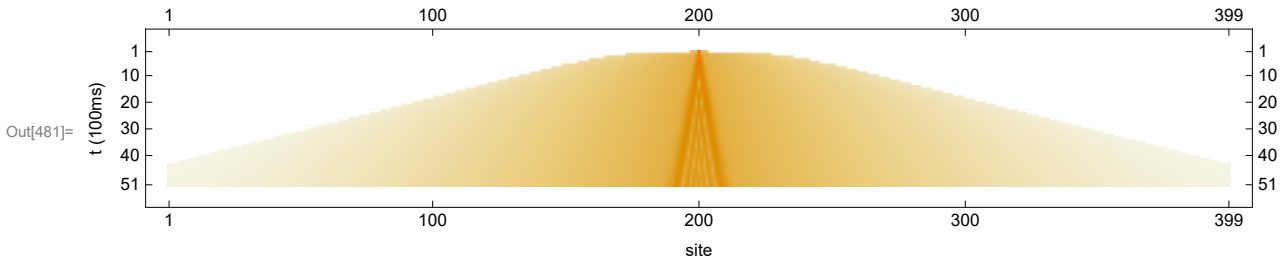
In[477]:= tmax = 5;
Table[Plot[{Re[ψ[t][[1, i]]], Im[ψ[t][[1, i]]], Norm[ψ[t][[1, i]]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - Nl/2], {i, Nl/2 - 5, Nl/2 + 5}]

```



```
In[479]:= (*λ[t_]:= MatrixExp[I H[Nl] t].ψ0;
Table[Plot[{Re[λ[t][[i]]], Im[λ[t][[i]]], Norm[λ[t][[i]]]}, {t, 0, tf},
  PlotLegends→{"Re","Im","Norm"}, AxesLabel→{"t", ""}, PlotLabel→i], {i, 1, Nl}]*)
```

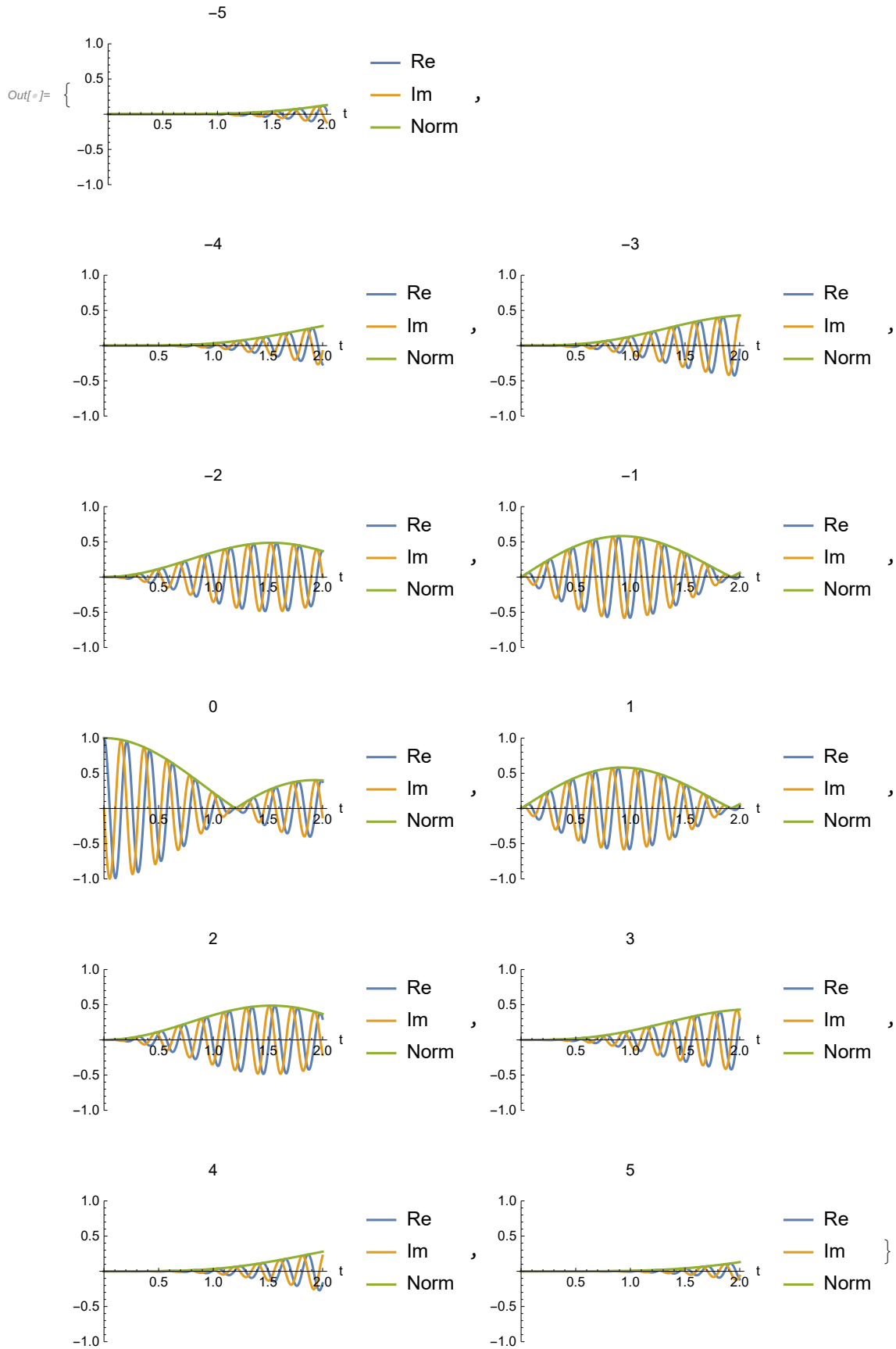
```
Out[481]= sitenum = 398;
tmax = 5;
MatrixPlot[Table[Abs[ψ[t][[1, i]]],
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],
  FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]
```



Larger force

```
In[482]:= ClearAll@ψ;
H[Nl_, F_] := Table[If[i == j, F * i, If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
Nl = 600;
tf = 10;
F = 0.15;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == H[Nl, F].ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];
```

```
In[483]:= tmax = 2;
Table[Plot[{Re[ψ[t][[1, i]]], Im[ψ[t][[1, i]]], Norm[ψ[t][[1, i]]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - Nl/2], {i, Nl/2 - 5, Nl/2 + 5}]
```



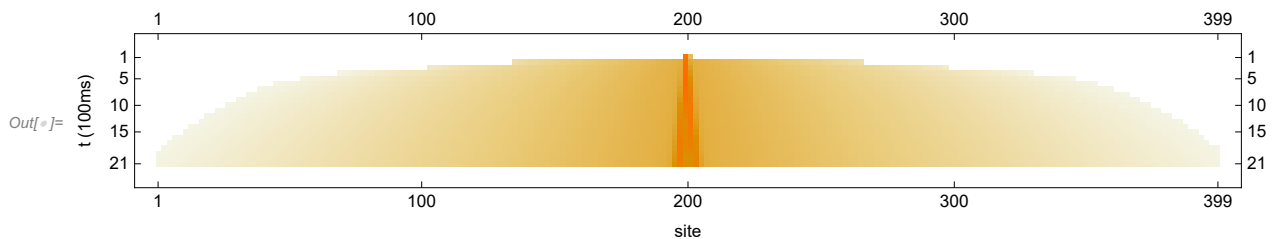

```
In[ ]:= sitenum = 398;
tmax = 2;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],
  FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]
```

General: $\frac{2.99558 \times 10^{-308}}{2}$ is too small to represent as a normalized machine number; precision may be lost.

General: $\frac{2.90704 \times 10^{-308}}{2}$ is too small to represent as a normalized machine number; precision may be lost.

General: $\frac{4.14107 \times 10^{-308}}{2}$ is too small to represent as a normalized machine number; precision may be lost.

General: Further output of General::munfl will be suppressed during this calculation.



Time dependent force term - NDSolve

```
In[412]:= Ht[Nl_, ω_, F_, t_] :=
  Table[If[i == j, F * i * Cos[ω * t], If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
Ht[10, 0.5, 0.5, t] // MatrixForm
```

```
Out[413]//MatrixForm=
{ 0.5 Cos[0.5 t]      -1      0      0      0      0
  -1      1. Cos[0.5 t]      -1      0      0      0
    0      -1      1.5 Cos[0.5 t]      -1      0      0
    0      0      -1      2. Cos[0.5 t]      -1      0
    0      0      0      -1      2.5 Cos[0.5 t]      -1
    0      0      0      0      -1      3. Cos[0.5 t]
    0      0      0      0      0      -1
    0      0      0      0      0      0
    0      0      0      0      0      0 }
```

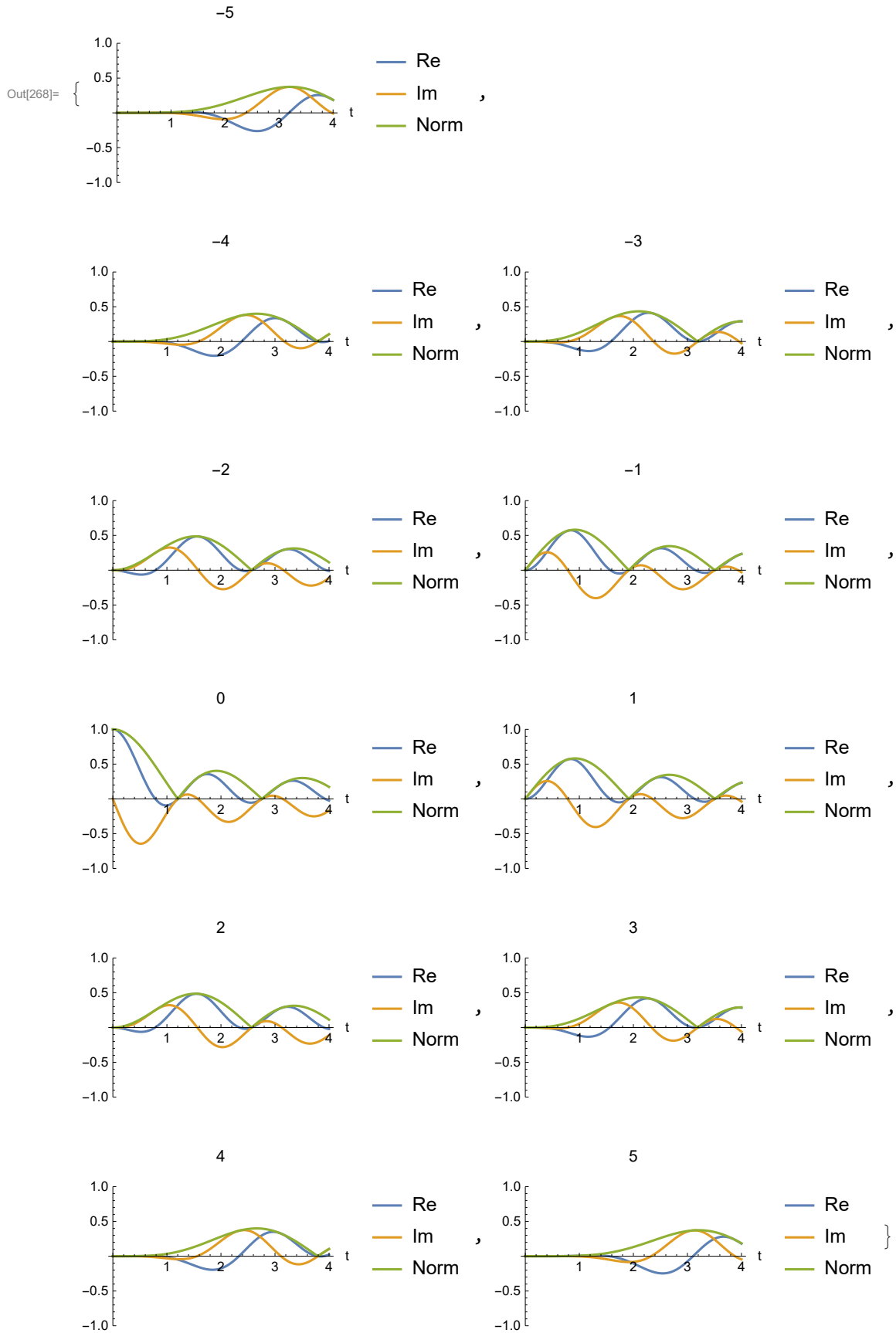
Low freq, Low A

```
In[332]:= ClearAll@ψ;
Ht[Nl_, ω_, F_, t_] :=
  Table[If[i == j, F * i * Cos[ω * t], If[Abs[i - j] == 1, -1, 0]], {i, 1, Nl}, {j, 1, Nl}];
Nl = 600;
tf = 10;
ω = 0.01;
F = 0.01;
ψ0 = Table[If[i == Nl/2, 1, 0], {i, 1, Nl}];
s = NDSolve[{ID[ψ[t], t] == Ht[Nl, F, ω, t] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];
```

```

In[267]:= tmax = 4;
Table[Plot[{Re[ψ[t]{{1, i}}], Im[ψ[t]{{1, i}}], Norm[ψ[t]{{1, i}}]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - N1/2], {i, N1/2 - 5, N1/2 + 5}]

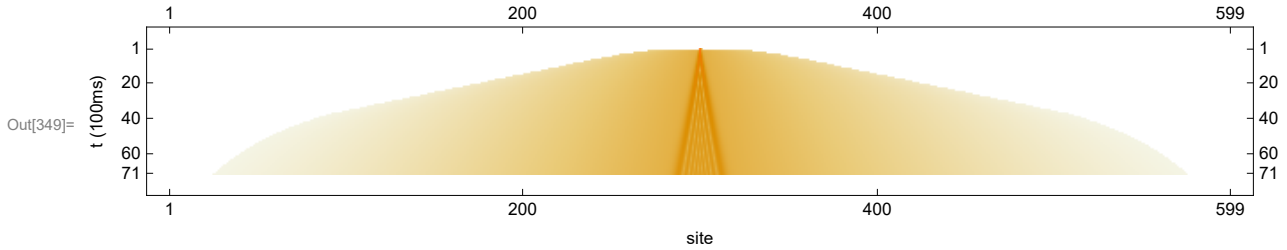
```



```

In[347]:= sitenum = 598;
tmax = 7;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, N1/2 - sitenum/2, N1/2 + sitenum/2}],
FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]

```



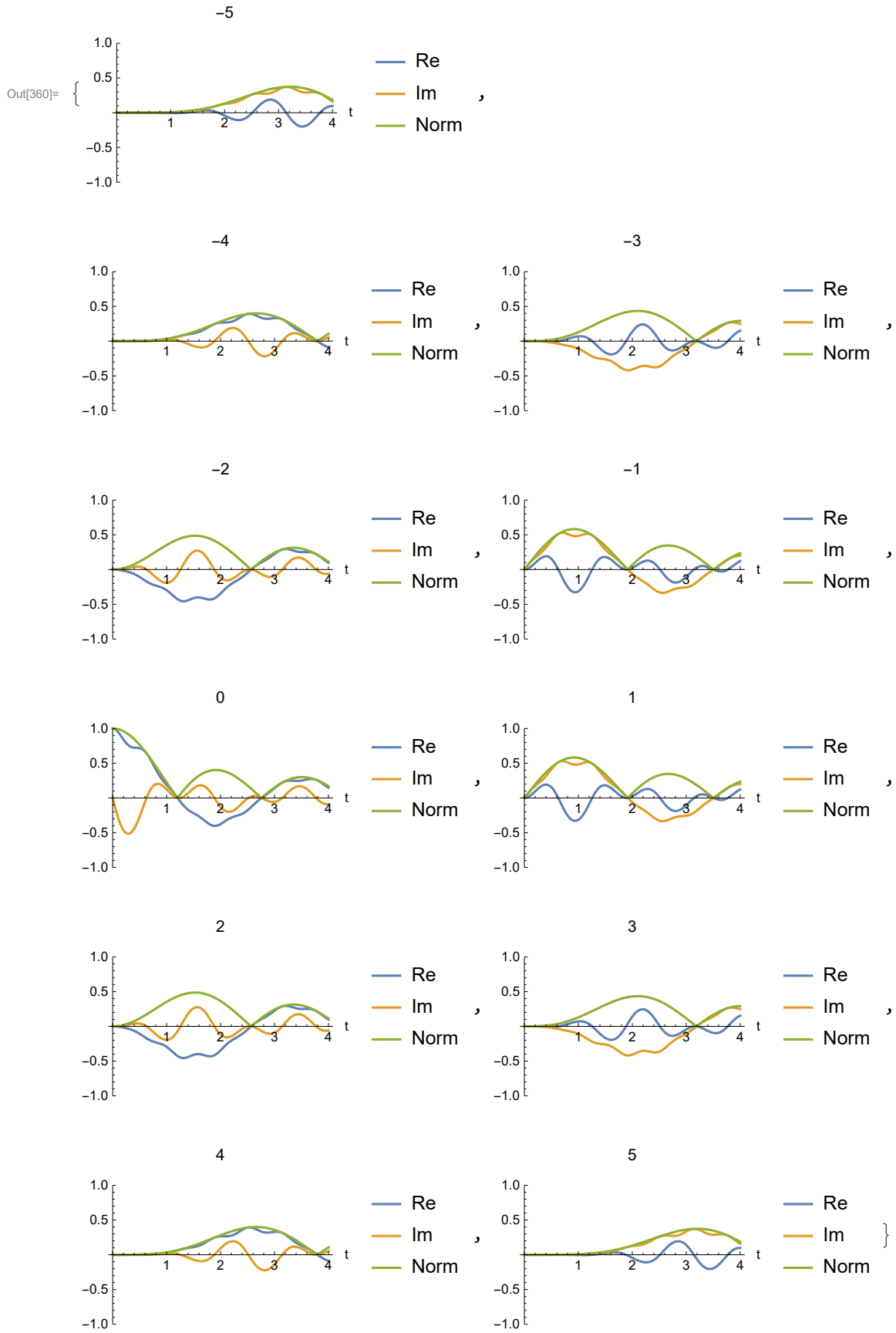
Low freq, High A

```

In[350]:= ClearAll@ψ;
Ht[N1_, ω_, F_, t_] :=
  Table[If[i == j, F * i * Cos[ω * t], If[Abs[i - j] == 1, -1, 0]], {i, 1, N1}, {j, 1, N1}];
N1 = 600;
tf = 10;
ω = 0.01;
F = 5;
ψ0 = Table[If[i == N1/2, 1, 0], {i, 1, N1}];
s = NDSolve[{ID[ψ[t], t] == Ht[N1, F, ω, t] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

In[359]:= tmax = 4;
Table[Plot[{Re[ψ[t]][[1, i]], Im[ψ[t]][[1, i]], Norm[ψ[t]][[1, i]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - N1/2], {i, N1/2 - 5, N1/2 + 5}]

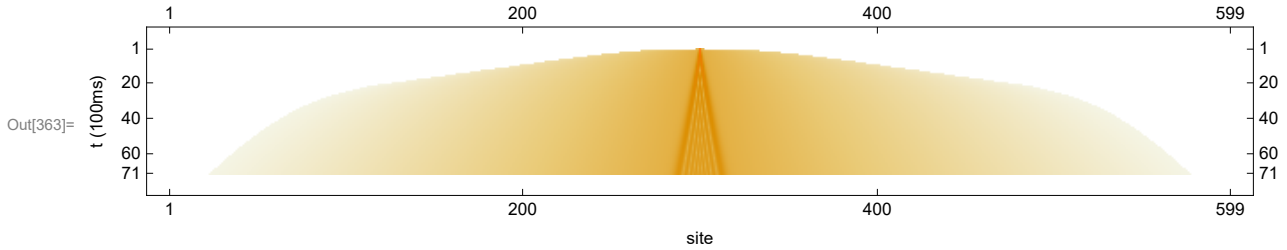
```



```

In[361]:= sitenum = 598;
tmax = 7;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, N1/2 - sitenum/2, N1/2 + sitenum/2}],
FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]

```



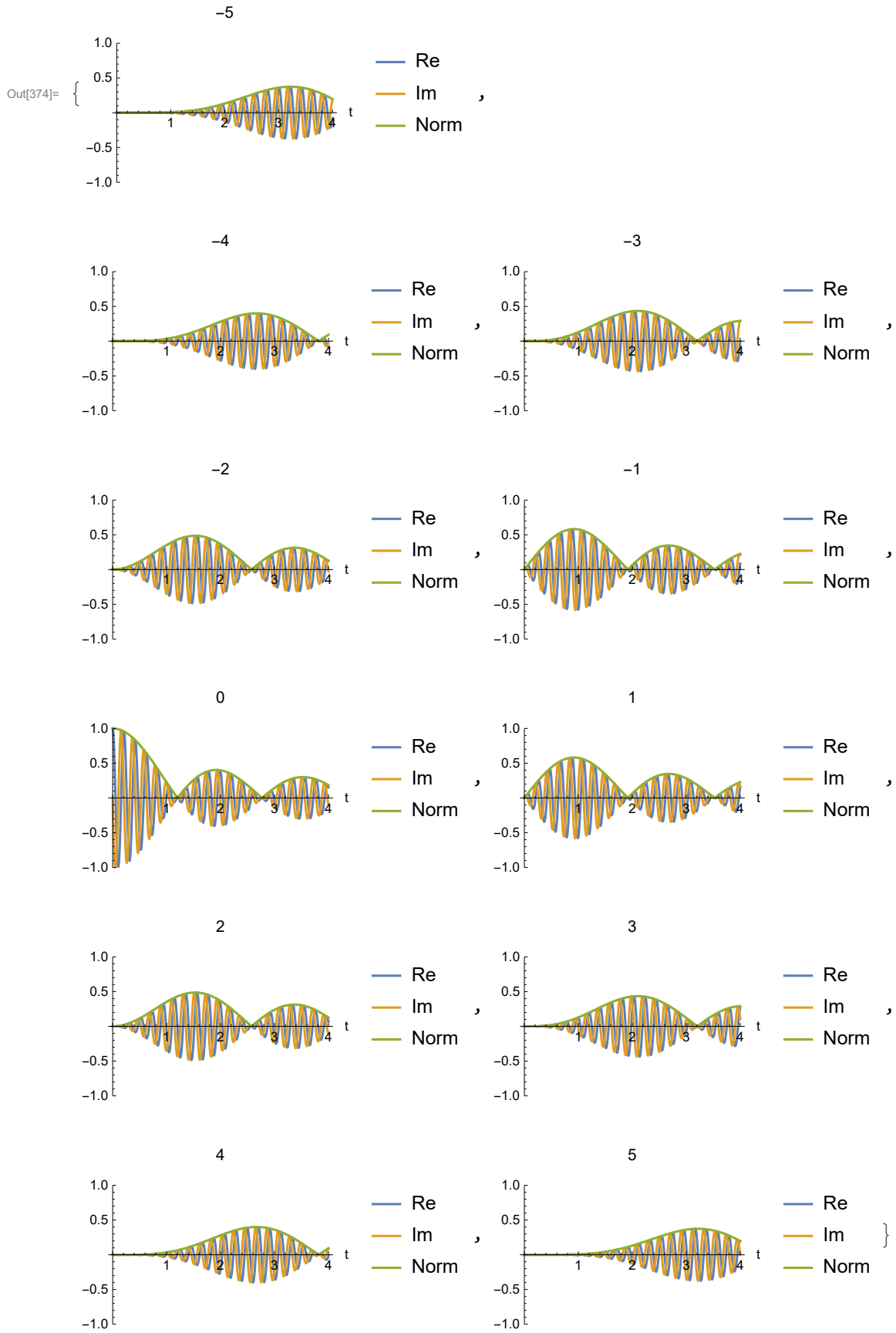
High freq, low A

```

In[364]:= ClearAll@ψ;
Ht[N1_, ω_, F_, t_] :=
  Table[If[i == j, F * i * Cos[ω * t], If[Abs[i - j] == 1, -1, 0]], {i, 1, N1}, {j, 1, N1}];
N1 = 600;
tf = 10;
ω = 0.1;
F = 0.01;
ψ0 = Table[If[i == N1/2, 1, 0], {i, 1, N1}];
s = NDSolve[{ID[ψ[t], t] == Ht[N1, F, ω, t] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

In[373]:= tmax = 4;
Table[Plot[{Re[ψ[t]][[1, i]], Im[ψ[t]][[1, i]], Norm[ψ[t]][[1, i]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - N1/2], {i, N1/2 - 5, N1/2 + 5}]

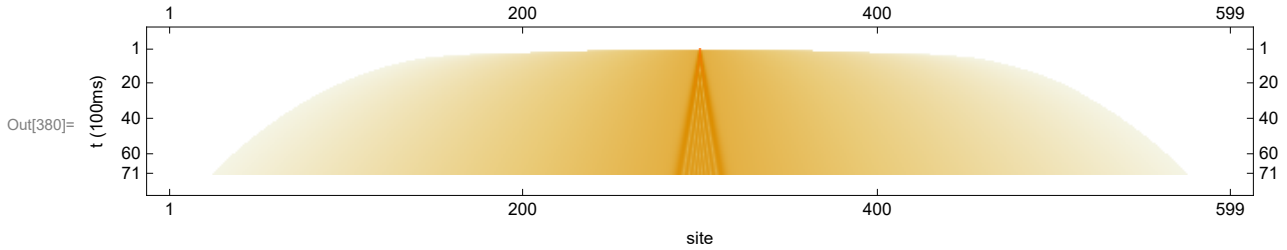
```



```

In[378]:= sitenum = 598;
tmax = 7;
MatrixPlot[Table[Abs[ψ[t]][[1, i]]],
  {t, 0, tmax, 0.1}, {i, N1/2 - sitenum/2, N1/2 + sitenum/2}],
FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]

```



High freq, high A

```

In[384]:= ClearAll@ψ;
Ht[N1_, ω_, F_, t_] :=
  Table[If[i == j, F * i * Cos[ω * t], If[Abs[i - j] == 1, -1, 0]], {i, 1, N1}, {j, 1, N1}];
N1 = 600;
tf = 10;
ω = 0.1;
F = 5;
ψ0 = Table[If[i == N1/2, 1, 0], {i, 1, N1}];
s = NDSolve[{ID[ψ[t], t] == Ht[N1, F, ω, t] . ψ[t], ψ[0] == ψ0}, ψ, {t, 0, tf}];
ψ[t_] = Evaluate[ψ[t] /. s];

In[393]:= tmax = 4;
Table[Plot[{Re[ψ[t]][[1, i]], Im[ψ[t]][[1, i]], Norm[ψ[t]][[1, i]]},
  {t, 0, tmax}, PlotLegends → {"Re", "Im", "Norm"}, PlotRange → {-1, 1},
  AxesLabel → {"t", ""}, PlotLabel → i - N1/2], {i, N1/2 - 5, N1/2 + 5}]

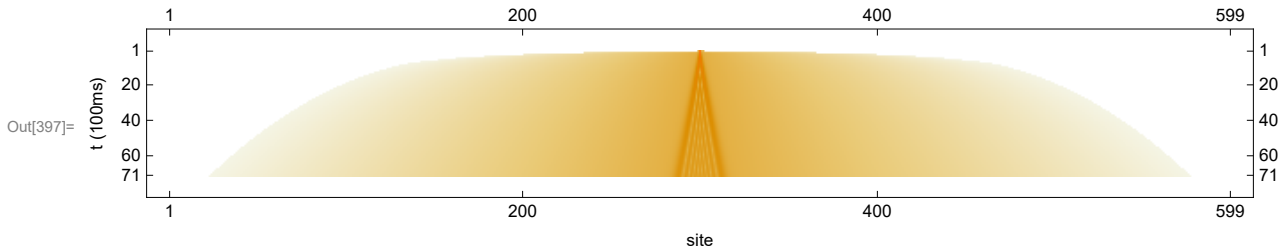
```



```
In[395]:= sitenum = 598;
```

```
tmax = 7;
```

```
MatrixPlot[Table[Abs[ψ[t][[i]]],  
  {t, 0, tmax, 0.1}, {i, Nl/2 - sitenum/2, Nl/2 + sitenum/2}],  
  FrameLabel → {"t (100ms)", "site"}, ImageSize → Full]
```



Random below..

```
(*Table[Plot[{Re[ψ[t][[i]]/.s], Im[ψ[t][[i]]/.s], Norm[ψ[t][[i]]/.s}],  
  {t, 0, 1}, PlotLegends → {"Re", "Im", "Norm"}], {i, 1, Nl}]  
Table[Plot[{Re[ψ[t][[i]]/.s], Im[ψ[t][[i]]/.s], Abs[ψ[t][[i]]/.s],  
  Norm[ψ[t][[i]]/.s]}, {i, 1, Nl}], {t, 0, 1, 0.1}]*)
```

```
In[*]:= tt = Range[0, 1, 0.1]
```

```
ww = Flatten[Evaluate[Abs[ψ[#]] /. s]] & /@ tt
```

```
Plot[tt, ww[[All, 2]]]
```

```
(*ListPlot[Table[Transpose[{tt, ww[[All, i]]}], {i, 3}]]
```

```
Out[*]= {0., 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.}
```

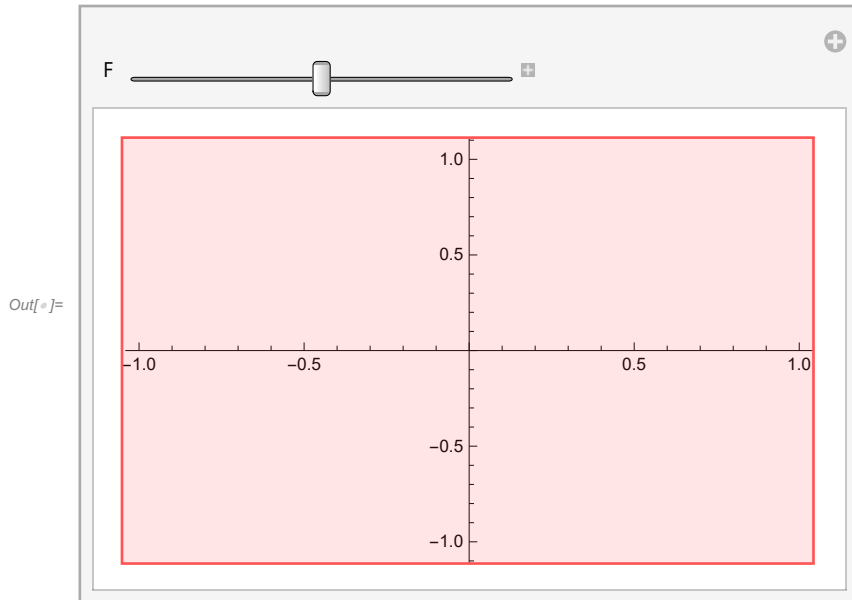
```
Out[*]= {{0., 0., 0., 0., 1., 0., 0., 0., 0., 0.},  
  {4.15962 × 10-6, 0.000166245, 0.00498335, 0.0995007, 0.990025,  
  0.0995007, 0.00498335, 0.000166245, 4.1582 × 10-6, 8.34361 × 10-8},  
  {0.0000662139, 0.00132003, 0.0197345, 0.196026, 0.960398, 0.196026,  
  0.0197345, 0.00132004, 0.0000661251, 2.65111 × 10-6},  
  {0.000332449, 0.0043995, 0.0436643, 0.286699, 0.912006, 0.286699, 0.0436644,  
  0.00439955, 0.000331447, 0.0000199874}, {0.00103847, 0.010246, 0.0758154,  
  0.368837, 0.846292, 0.368837, 0.0758154, 0.0102463, 0.0010329, 0.0000833934},  
  {0.0024973, 0.0195605, 0.114898, 0.440042, 0.765209, 0.440042, 0.114898,  
  0.019562, 0.00247628, 0.000251213}, {0.00508345, 0.0328656, 0.159339,  
  0.498277, 0.671155, 0.498277, 0.159339, 0.032871, 0.00502154, 0.000615288},  
  {0.00921334, 0.0504753, 0.20734, 0.541935, 0.566894, 0.541935, 0.207338,  
  0.0504908, 0.00905977, 0.00130516}, {0.0153233, 0.0724723, 0.256945,  
  0.569885, 0.455463, 0.569885, 0.256941, 0.072511, 0.0149876, 0.00248993},  
  {0.0238457, 0.098695, 0.306117, 0.581513, 0.340075, 0.581514, 0.306107,  
  0.0987815, 0.0231796, 0.00437753}, {0.0351842, 0.128736, 0.352809,  
  0.576736, 0.224011, 0.576738, 0.352787, 0.128913, 0.0339609, 0.00721095}}
```


Plot: Range specification

{0., 0.000166245, 0.00132003, 0.0043995, 0.010246, 0.0195605, 0.0328656, 0.0504753, 0.0724723, 0.098695, 0.128736} is not of the form {x, xmin, xmax}.

```
Out[*]= Plot[tt, ww[[All, 2]]]
```

```
in[*]:= Manipulate[Module[{ψ, sol, tmax = 20},
  sol = First@NDSolve[{ID[ψ[t], t] ==
    Ht[10, 0.05, F, t].ψ[t], ψ[0] == psi0}, ψ, {t, 0, 1}];
  Plot[Chop[#] &@ (ψ /. sol)[t],
    {t, 0, 1}, PlotRange → All]
],
{{F, 1}, 0, 2}
]
```



 Dot: Tensors

$\{0, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 0, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 0, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 0, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 0, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 0, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 0, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 0, -1\}, \{0, 0, 0, 0, 0, 0, 0, -1, 0\}$ and $\{0, 0, 0, 0, 0, 0, 0, 0, 0, 0\}$ have incompatible shapes.

 Dot: Tensors

[illegible]

 **NDSolve:** Encountered non-numerical value for a derivative at t == 0.`

 ReplaceAll:

`{# $47839[0.0000204286] == {{ {0., -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 0., -1, 0, 0, 0, 0, 0, 0}, {0, -1, 0., -1, 0, 0, 0, 0, 0}, {0, 0, -1, 0., -1, 0, 0, 0, 0}, {0, 0, 0, -1, 0., -1, 0, 0, 0}, {0, 0, 0, 0, -1, 0., -1, 0, 0}, {0, 0, 0, 0, 0, -1, 0., -1, 0}, {0, 0, 0, 0, 0, 0, -1, 0., -1}, {0, 0, 0, 0, 0, 0, 0, -1, 0.}}, $47839[0.0000204286], $47839[] == {0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0}}}` is neither a list of replacement rules nor a valid dispatch table,
and so cannot be used for replacing.

 **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
 $+ 1. i) \psi_{47839}[0.0000204286] == \{ \{0., -1., 0., 0., 0., 0., 0., 0., 0.\}, \{-1., 0., -1., 0., 0., 0., 0., 0., 0.\}, \{0., -1., 0., -1., 0., 0., 0., 0., 0.\}, \{0., 0., -1., 0., -1., 0., 0., 0., 0.\}, \{0., 0., 0., -1., 0., -1., 0., 0., 0.\}, \{0., 0., 0., 0., -1., 0., -1., 0., 0.\}, \{0., 0., 0., 0., 0., -1., 0., -1., 0.\}, \{0., 0., 0., 0., 0., 0., -1., 0., -1.\}, \{0., 0., 0., 0., 0., 0., 0., -1., 0.\} \}.$ $\psi_{47839}[0.0000204286], \psi_{47839}[0.] == \{0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i $\psi_{47839}[0.0204286] == \{ \{0., -1., 0., 0., 0., 0., 0., 0., 0.\}, \{-1., 0., -1., 0., 0., 0., 0., 0., 0.\}, \{0., -1., 0., -1., 0., 0., 0., 0., 0.\}, \{0., 0., -1., 0., -1., 0., 0., 0., 0.\}, \{0., 0., 0., -1., 0., -1., 0., 0., 0.\}, \{0., 0., 0., 0., -1., 0., -1., 0., 0.\}, \{0., 0., 0., 0., 0., -1., 0., -1.\}, \{0., 0., 0., 0., 0., 0., -1., 0.\} \}.$ $\psi_{47839}[0.0204286], \psi_{47839}[0.] == \{0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** There are more dependent variables, {Ht[10, 0.05, 0., t], $\psi_{10492}[t]$ }, than equations, so the system is underdetermined.

... **ReplaceAll:**

{i $\psi_{10492}[0.0000204286] == \text{Ht}[10, 0.05, 0., 0.0000204286].\psi_{10492}[0.0000204286], \psi_{10492}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
 $+ 1. i) \psi_{10492}[0.0000204286] == \text{Ht}[10., 0.05, 0., 0.0000204286].\psi_{10492}[0.0000204286], \psi_{10492}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i $\psi_{10492}[0.0204286] == \text{Ht}[10, 0.05, 0., 0.0204286].\psi_{10492}[0.0204286], \psi_{10492}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** There are more dependent variables, {Ht[10, 0.05, 0., t], $\psi_{21062}[t]$ }, than equations, so the system is underdetermined.

... **ReplaceAll:**

{i $\psi_{21062}[0.0000204286] == \text{Ht}[10, 0.05, 0., 0.0000204286].\psi_{21062}[0.0000204286], \psi_{21062}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0.\}$
 }} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) $\psi_{21062}[0.0000204286] == \text{Ht}[10., 0.05, 0., 0.0000204286].\psi_{21062}[0.0000204286]$, $\psi_{21062}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0., 0.\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i $\psi_{21062}[0.0204286] == \text{Ht}[10, 0.05, 0., 0.0204286].\psi_{21062}[0.0204286]$, $\psi_{21062}[0] == \{0, 0, 0, 0, 1, 0, 0, 0, 0, 0\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** There are more dependent variables, {Ht[10, 0.05, 1.005, t], $\psi_{21634}[t]$ }, than equations, so the system is underdetermined.

... **ReplaceAll:**

{i $\psi_{21634}[0.0000204286] == \text{Ht}[10, 0.05, 1.005, 0.0000204286].\psi_{21634}[0.0000204286]$, $\psi_{21634}[0] == \{0, 0, 0, 0, 1, 0, 0, 0, 0, 0\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) $\psi_{21634}[0.0000204286] == \text{Ht}[10., 0.05, 1.005, 0.0000204286].\psi_{21634}[0.0000204286]$, $\psi_{21634}[0.] == \{0., 0., 0., 0., 1., 0., 0., 0., 0., 0.\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i $\psi_{21634}[0.0204286] == \text{Ht}[10, 0.05, 1.005, 0.0204286].\psi_{21634}[0.0204286]$, $\psi_{21634}[0] == \{0, 0, 0, 0, 1, 0, 0, 0, 0, 0\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i $\psi_{31817}[0.0000204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{31817}[0.0000204286]$, $\psi_{31817}[0] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$31817'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1.
, 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0.,
0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0.,
0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$31817[0.0000204286], ψ$31817[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$31817'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$31817[
0.0204286], ψ$31817[0] == psi0} is neither a list of replacement rules nor a valid dispatch
```

table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

```
{i ψ$40649'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
-1, 4.02, -1, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1,
1, 0, 0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$40649
[0.0000204286], ψ$40649[0] == psi0} is neither a list of replacement rules nor a valid
```

dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$40649'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1.
, 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0.,
0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0.,
0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$40649[0.0000204286], ψ$40649[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$40649'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$40649[
0.0204286], ψ$40649[0] == psi0} is neither a list of replacement rules nor a valid dispatch
```

table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

$\{i \mid \psi_{50407}[0.0000204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{50407}[0.0000204286], \psi_{50407}[0] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

$\{0. + 1. i\} \psi_{50407}[0.0000204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{50407}[0.0000204286], \psi_{50407}[0.] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

$\{i \mid \psi_{50407}[0.0204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{50407}[0.0204286], \psi_{50407}[0] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

$\{i \mid \psi_{31845}[0.0000204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{31845}[0.0000204286], \psi_{31845}[0] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

$\{0. + 1. i\} \psi_{31845}[0.0000204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{31845}[0.0000204286], \psi_{31845}[0.] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

$\{i \mid \psi_{31845}[0.0204286] == \{\{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0\}, \{-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0\}, \{0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0\}, \{0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0\}, \{0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0\}, \{0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0\}, \{0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0\}, \{0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0\}, \{0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1\}, \{0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05\}\}.\psi_{31845}[0.0204286], \psi_{31845}[0] == \text{psi0}\}$ is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$35202'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35202[0.0000204286], ψ\$35202[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0. + 1. i) ψ\$35202'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$35202[0.0000204286], ψ\$35202[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$35202'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35202[0.0204286], ψ\$35202[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$35375'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35375[0.0000204286], ψ\$35375[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0. + 1. i) ψ\$35375'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$35375[0.0000204286], ψ\$35375[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$35375'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35375[0.0204286], ψ\$35375[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$35546'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35546[0.0000204286], ψ\$35546[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0. + 1. i) ψ\$35546'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35546[0.0000204286], ψ\$35546[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$35546'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$35546[0.0204286], ψ\$35546[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$3561'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$3561[0.0000204286], ψ\$3561[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$3561'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1.,
3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0.,
-1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0.,
0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$3561[0.0000204286], ψ$3561[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$3561'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$3561[
0.0204286], ψ$3561[0] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

```
{i ψ$5884'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1,
1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035,
-1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$5884[
0.0000204286], ψ$5884[0] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$5884'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1.,
3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0.,
-1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0.,
0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$5884[0.0000204286], ψ$5884[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$5884'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$5884[
0.0204286], ψ$5884[0] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$11990'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$11990[0.0000204286], ψ\$11990[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) ψ\$11990'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$11990[0.0000204286], ψ\$11990[0.] == psi0}
is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$11990'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$11990[0.0204286], ψ\$11990[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$16791'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$16791[0.0000204286], ψ\$16791[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) ψ\$16791'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$16791[0.0000204286], ψ\$16791[0.] == psi0}
is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$16791'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$16791[0.0204286], ψ\$16791[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General**: Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **General**: Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve**: Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll**:

```
{i ψ$24418'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$24418[0.0000204286], ψ$24418[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll**:

```
{(0. + 1. i) ψ$24418'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$24418[0.0000204286], ψ$24418[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll**:

```
{i ψ$24418'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$24418[0.0204286], ψ$24418[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **General**: Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **General**: Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve**: Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll**:

```
{i ψ$24524'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$24524[0.0000204286], ψ$24524[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll**:

```
{(0. + 1. i) ψ$24524'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$24524[0.0000204286], ψ$24524[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$24524'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$24524[0.0204286], ψ\$24524[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$24632'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$24632[0.0000204286], ψ\$24632[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) ψ\$24632'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$24632[0.0000204286], ψ\$24632[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$24632'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$24632[0.0204286], ψ\$24632[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$25687'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$25687[0.0000204286], ψ\$25687[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$25687'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1.
, 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0.,
0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0.,
0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$25687[0.0000204286], ψ$25687[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$25687'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$25687[
0.0204286], ψ$25687[0] == psi0} is neither a list of replacement rules nor a valid dispatch
```

table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

```
{i ψ$25887'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
-1, 4.02, -1, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$25887[
0.0000204286], ψ$25887[0] == psi0} is neither a list of replacement rules nor a valid
```

dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$25887'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1.
, 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0.,
0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0.,
0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$25887[0.0000204286], ψ$25887[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$25887'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$25887[
0.0204286], ψ$25887[0] == psi0} is neither a list of replacement rules nor a valid dispatch
```

table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

```
{i ψ$26085'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$26085[0.0000204286], ψ$26085[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0. + 1. i) ψ$26085'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$26085[0.0000204286], ψ$26085[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$26085'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$26085[0.0204286], ψ$26085[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

```
{i ψ$26256'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$26256[0.0000204286], ψ$26256[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0. + 1. i) ψ$26256'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$26256[0.0000204286], ψ$26256[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$26256'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$26256[0.0204286], ψ$26256[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
```

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$28828'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$28828[0.0000204286], ψ\$28828[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0. + 1. i) ψ\$28828'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$28828[0.0000204286], ψ\$28828[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$28828'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$28828[0.0204286], ψ\$28828[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$28997'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1, 0, 0, 0, 0, 0}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$28997[0.0000204286], ψ\$28997[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0. + 1. i) ψ\$28997'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1., 0., 0., 0., 0., 0.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$28997[0.0000204286], ψ\$28997[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$28997'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$28997[0.0204286], ψ\$28997[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$30141'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$30141[0.0000204286], ψ\$30141[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{(0.
+ 1. i) ψ\$30141'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1., 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 6.03, -1., 0., 0.}, {0., 0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0., 0., 0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ\$30141[0.0000204286], ψ\$30141[0.] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

{i ψ\$30141'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$30141[0.0204286], ψ\$30141[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

... **NDSolve:** Initial condition psi0 is not a number or a rectangular array of numbers.

... **ReplaceAll:**

{i ψ\$30273'[0.0000204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1, 4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, 0, -1, 7.035, -1, 0, 0}, {0, 0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ\$30273[0.0000204286], ψ\$30273[0] == psi0} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{(0.
+ 1. i) ψ$30273'[0.0000204286] == {{1.005, -1., 0., 0., 0., 0., 0., 0., 0.}, {-1., 2.01, -1., 0., 0., 0., 0., 0., 0.}, {0., -1.
, 3.015, -1., 0., 0., 0., 0., 0.}, {0., 0., -1., 4.02, -1., 0., 0., 0., 0.}, {0., 0., 0., -1., 5.025, -1., 0., 0., 0.}, {0., 0., 0.,
0., -1., 6.03, -1., 0., 0., 0.}, {0., 0., 0., 0., -1., 7.035, -1., 0., 0.}, {0., 0., 0., 0., -1., 8.04, -1., 0.}, {0., 0., 0., 0.,
0., 0., -1., 9.045, -1.}, {0., 0., 0., 0., 0., 0., -1., 10.05}}.ψ$30273[0.0000204286], ψ$30273[0.] == psi0}
```

is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll:**

```
{i ψ$30273'[0.0204286] == {{1.005, -1, 0, 0, 0, 0, 0, 0, 0}, {-1, 2.01, -1, 0, 0, 0, 0, 0, 0}, {0, -1, 3.015, -1, 0, 0, 0, 0, 0}, {0, 0, -1,
4.02, -1, 0, 0, 0, 0}, {0, 0, 0, -1, 5.025, -1, 0, 0, 0}, {0, 0, 0, 0, -1, 6.03, -1, 0, 0}, {0, 0, 0, 0, -1, 7.035, -1, 0,
0}, {0, 0, 0, 0, 0, -1, 8.04, -1, 0}, {0, 0, 0, 0, 0, 0, -1, 9.045, -1}, {0, 0, 0, 0, 0, 0, 0, -1, 10.05}}.ψ$30273[
0.0204286], ψ$30273[0] == psi0} is neither a list of replacement rules nor a valid dispatch
```

table, and so cannot be used for replacing.

... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.

... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.

Create U

```
In[ ]:= ClearAll@constructU;
constructU[h_, tinit_, tfinal_, n_] := Module[{dt = N[(tfinal - tinit)/n],
  curVal = IdentityMatrix[Length@h[0]]},
  Do[curVal = MatrixExp[-I * h[t] * dt].curVal, {t, tinit, tfinal - dt, dt}];
  curVal]

N1 = 10;
psi0 = Table[If[i == N1/2, 1, 0], {i, 1, N1}];

constructU[Ht[N1, 0.01, 0. × 10], 0, 0.1, 10].psi0
(*ListLinePlot[
  Chop[constructU[Ht[N1, 0.01, 0, 10], 0, 0.1, 10]].psi0, PlotRange→All]*)
(*ListPlot[sortedEVecs[[1]], PlotRange→All], *)

In[ ]:= ListPlot[
  Table[Chop[constructU[Ht[N1, 0.01, 0.01, #].psi0 &, 0, upt, 100]],
    {upt, .1, 1, .1}
  ],
  Joined → True,
  PlotRange → {-1, 1}
]
```

```

ListPlot[
  Table[
    Chop[#] &@ (constructU[
      Ht[Nl, 0.05, F, #] &, 0, upt, 100].psi0),
    {upt, .01, 20, .1}
  ],
  Joined → True,
  PlotRange → {-1, 1}
]

ham[e1_, e2_, b_, omega_, t_] := {{e1, b * Cos[omega * t]}, {b * Cos[omega * t], e2}};
Module[{ψ, sol, tmax = 20},
  sol = NDSolve[
    {ID[ψ[t], t] == Ht[10, 0.05, 0.05, t] . ψ[t], ψ[0] == psi0}, ψ, {t, 0, tMax}];
Module[{ψ, sol, tmax = 20},
  sol = First@NDSolve[{ID[ψ[t], t] ==
    Ht[10, 0.05, 0.05, t] . ψ[t], ψ[0] == psi0}, ψ, {t, 0, tMax}];
  Plot[Chop[#].PauliMatrix[3].#] &@ (ψ /. sol)[t],
    {t, 0, tMax}, PlotRange → {-1, 1}]
]

```

Create U (2x2)

```

ham[e1_, e2_, b_, omega_, t_] := {{e1, b * Cos[omega * t]}, {b * Cos[omega * t], e2}}

ClearAll@constructU;
constructU[h_, tinit_, tfinal_, n_] := Module[{dt = N[(tfinal - tinit) / n],
  curVal = IdentityMatrix[Length@h[0]]},
  Do[curVal = MatrixExp[-I * h[t] * dt].curVal, {t, tinit, tfinal - dt, dt}];
  curVal]

ClearAll[cU, psi0];
psi0 = {1., 0};
Manipulate[
  ListPlot[
    Table[
      Chop[#.PauliMatrix[3].#] &@ (constructU[
        ham[-1., 1., b, 1., #] &, 0, upt, 100].psi0),
      {upt, .01, 20, .1}
    ],
    Joined → True,
    PlotRange → {-1, 1}
  ],
  {b, 0, 2}
]

```

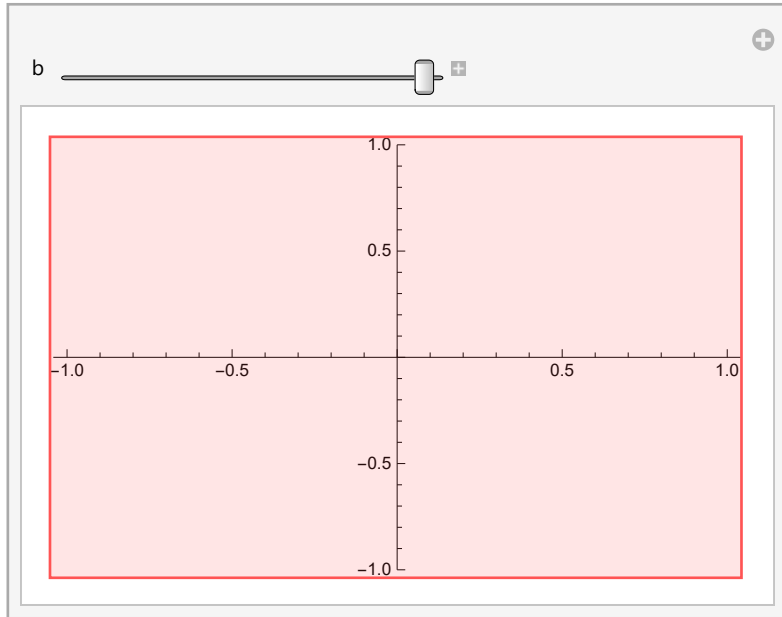
NDsolve (2x2)

```

In[ ]:= Manipulate[Module[{ψ, sol, tmax = 20},
  sol = First@NDSolve[{ID[ψ[t], t] ==
    ham[-1, 1, b, 1, t].ψ[t], ψ[0] == {1, 0}}, ψ, {t, 0, 1}];
  Plot[Chop[#*.PauliMatrix[3].#] &@ (ψ /. sol)[t],
    {t, 0, 1}, PlotRange → {-1, 1}]
],
{b, 1}, 0, 2]

```

Out[]:=



- ... **NDSolve:** There are more dependent variables, {ham[-1, 1, 2., 1, t], ψ\$3484[t]}, than equations, so the system is underdetermined.
- ... **ReplaceAll:** {i ψ\$3484'[0.0000204286] == ham[-1, 1, 2., 1, 0.0000204286].ψ\$3484[0.0000204286], ψ\$3484[0] == {1, 0}} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
- ... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.
- ... **ReplaceAll:**

{(0. + 1. i) ψ\$3484'[0.0000204286] == ham[-1., 1., 2., 1., 0.0000204286].ψ\$3484[0.0000204286], ψ\$3484[0.] == {1., 0.}} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
- ... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.
- ... **ReplaceAll:**

{(0. + 1. i) ψ\$3484'[0.0000204286] == ham[-1., 1., 2., 1., 0.0000204286].ψ\$3484[0.0000204286], ψ\$3484[0.] == {1., 0.}} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.
- ... **General:** Further output of ReplaceAll::reps will be suppressed during this calculation.
- ... **ReplaceAll:** ReplaceAll called with 2 arguments; 1 argument is expected.
- ... **General:** Further output of ReplaceAll::argx will be suppressed during this calculation.
- ... **NDSolve:** There are more dependent variables, {ham[-1, 1, 2., 1, t], ψ\$23790[t]}, than equations, so the system is underdetermined.
- ... **ReplaceAll:** {i ψ\$23790'[0.0000204286] == ham[-1, 1, 2., 1, 0.0000204286].ψ\$23790[0.0000204286], ψ\$23790[0] == {1, 0}} is neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll**:

$\{(0. + 1. i) \psi_{23790}'[0.0000204286] == \text{ham}[-1., 1., 2., 1., 0.0000204286]. \psi_{23790}[0.0000204286], \psi_{23790}[0.] == \{1., 0.\}\}$ is
neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **ReplaceAll**:

$\{(0. + 1. i) \psi_{23790}'[0.0000204286] == \text{ham}[-1., 1., 2., 1., 0.0000204286]. \psi_{23790}[0.0000204286], \psi_{23790}[0.] == \{1., 0.\}\}$ is
neither a list of replacement rules nor a valid dispatch table, and so cannot be used for replacing.

... **General**: Further output of ReplaceAll::reps will be suppressed during this calculation.

... **ReplaceAll**: ReplaceAll called with 2 arguments; 1 argument is expected.

... **General**: Further output of ReplaceAll::argx will be suppressed during this calculation.