

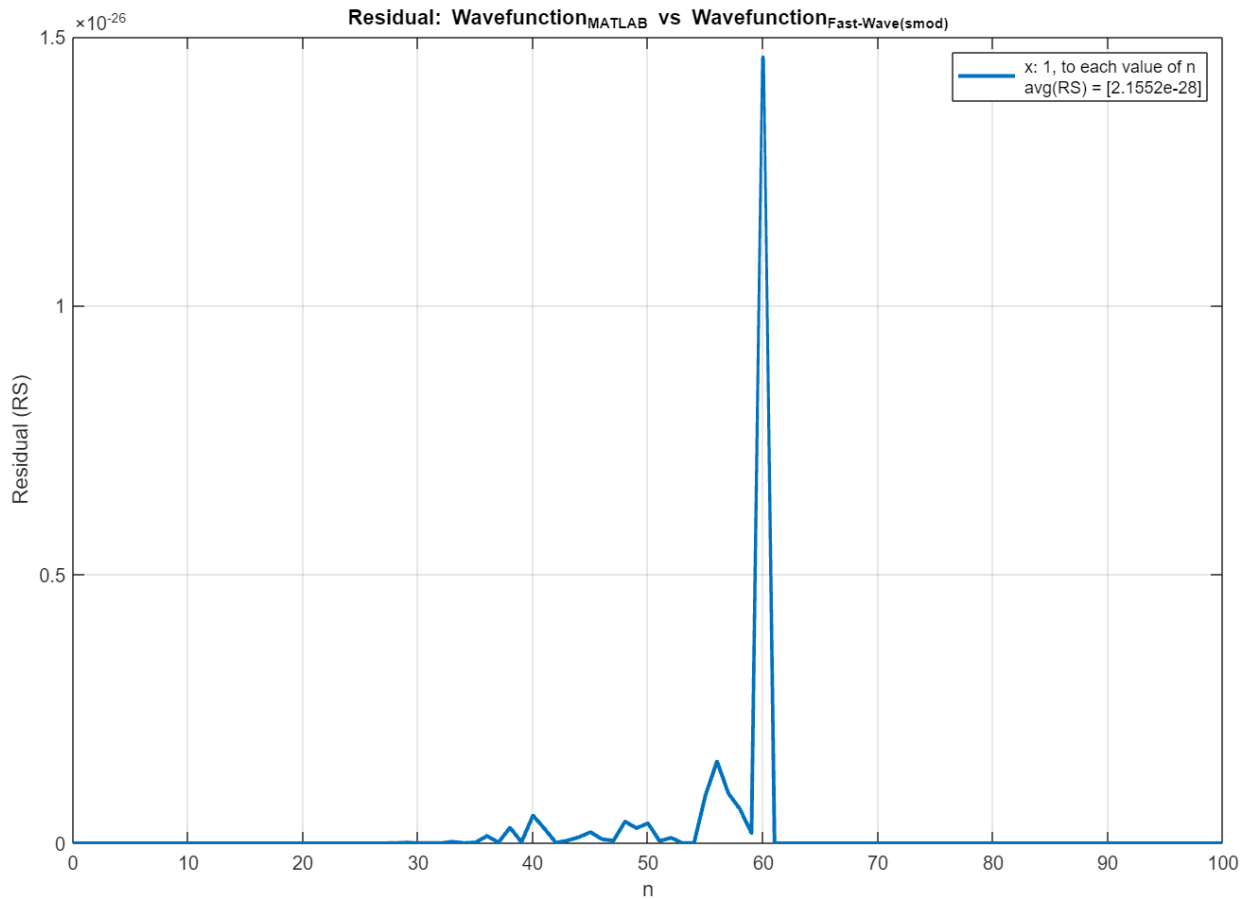
Global Variables

```
prec = 100;  
digits(prec);
```

Tests

Single-Mode and Onedimensional Function with $x = 1.0$

```
import py.fast_wave.wavefunction.wavefunction_smod  
  
N_max = 100;  
x = 1.0;  
  
Residual = vpa(zeros(N_max+1, 1));  
x_axi_plot = linspace(0,N_max,N_max+1);  
  
for index = 1:N_max+1  
    Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -  
vpa(wavefunction_smod(uint64(index-1), x)))^2;  
end  
  
figure('Position', [100, 100, 1200, 800]);  
plot(x_axi_plot, Residual, 'LineWidth', 2);  
grid on;  
  
xlabel('n');  
ylabel('Residual (RS)');  
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = ['+  
string(double(mean(Residual)))+']'));  
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod)}');
```



Single-Mode and Onedimensional Less Fast Function with $x = 1.0$

```
import py.fast_wave.wavefunction.wavefunction_smod

N_max = 100;
x = 1.0;

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -
vpa(wavefunction_smod(uint64(index-1), x, more_fast = false)))^2;
end

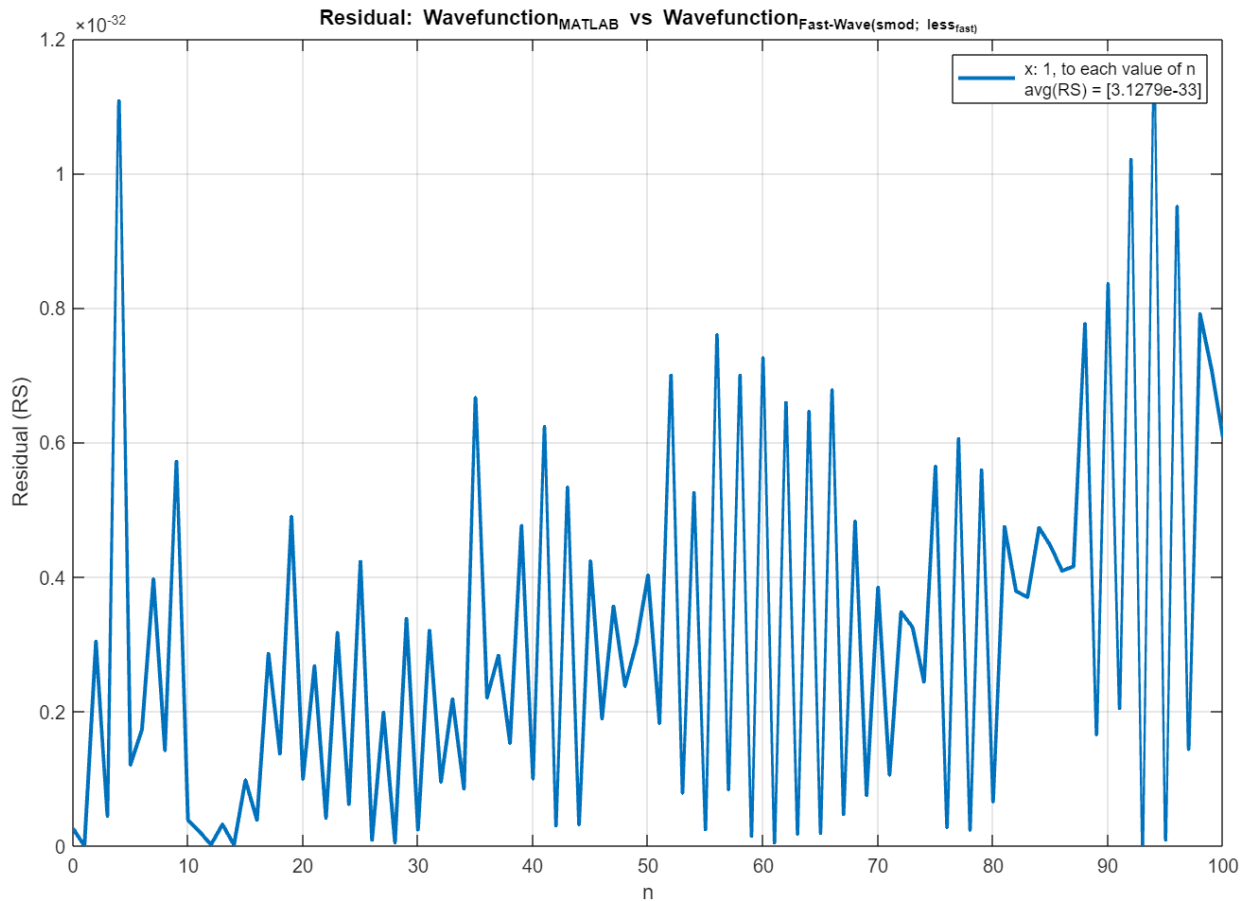
figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
```

```

ylabel('Residual (RS)');
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = [' +
string(double(mean(Residual))))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod;
less_fast)}');

```



Single-Mode and Onedimensional Function with $x = 10.0$

```

import py.fast_wave.wavefunction.wavefunction_smod

N_max = 100;
x = 10.0;

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -
vpa(wavefunction_smod(uint64(index-1), x)))^2;
end

figure('Position', [100, 100, 1200, 800]);

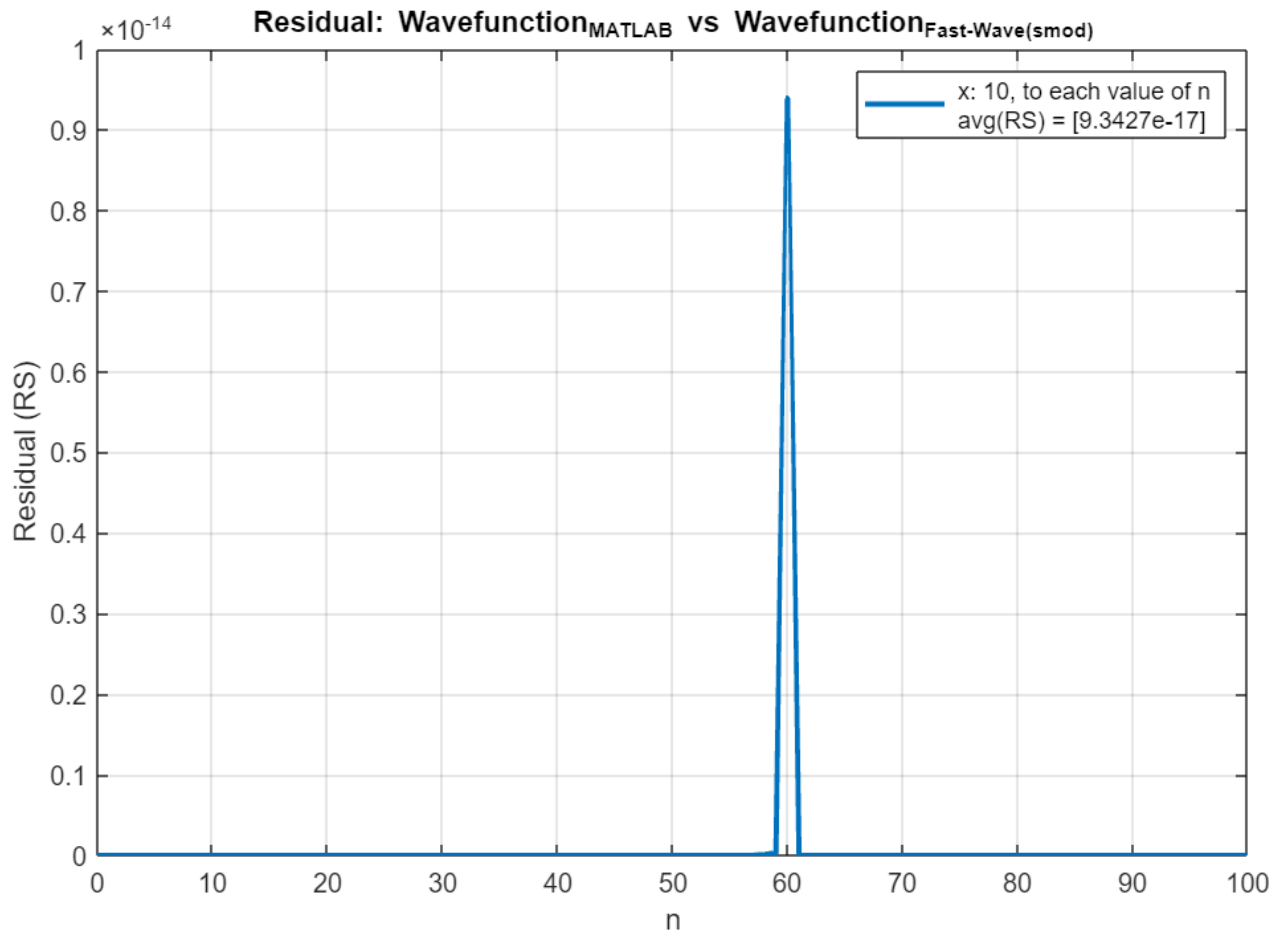
```

```

plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = ['+
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod)}');

```



Single-Mode and Onedimensional Less Fast Function with $x = 10.0$

```

import py.fast_wave.wavefunction.wavefunction_smod

N_max = 100;
x = 10.0;

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1

```

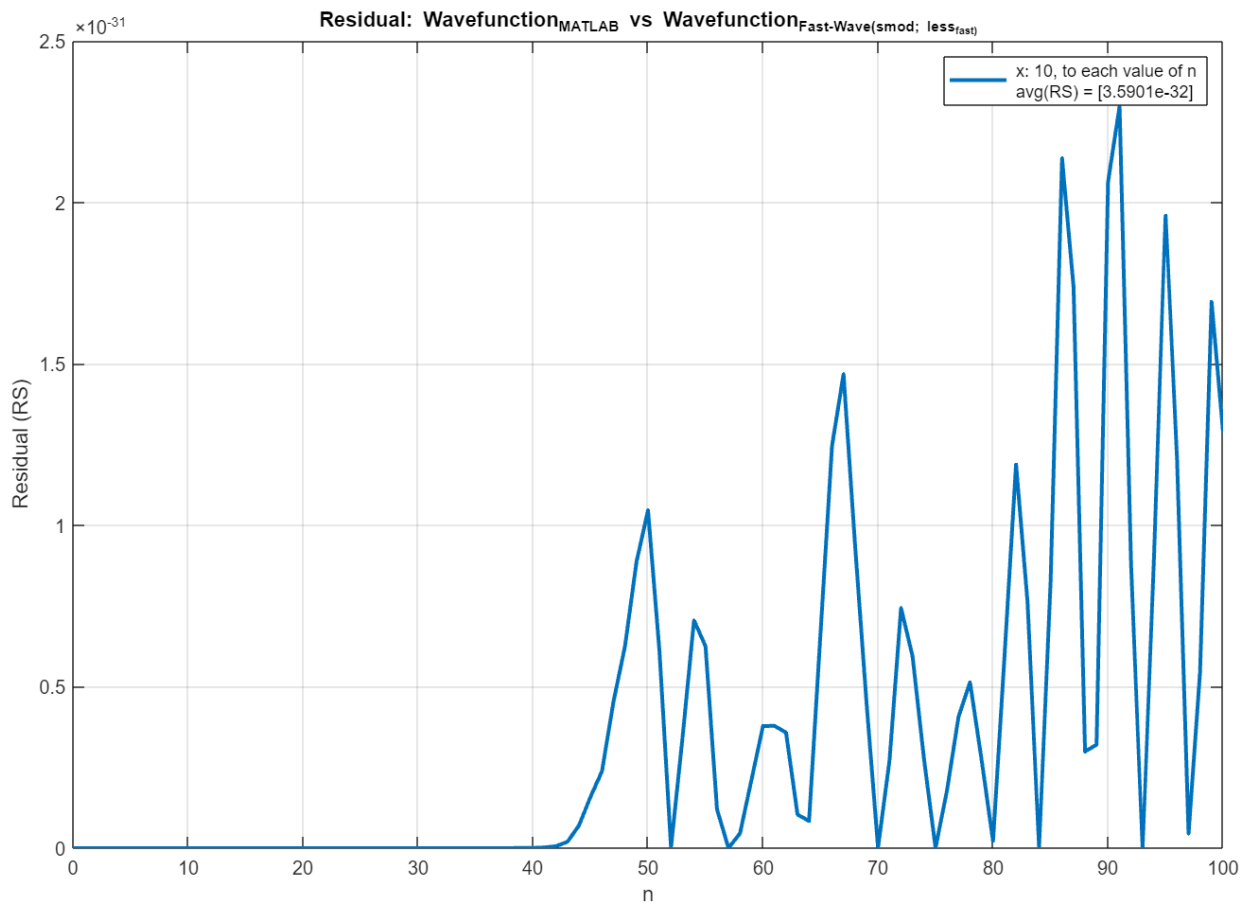
```

Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -
vpa(wavefunction_smod(uint64(index-1), x, more_fast=false)))^2;
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = ['+
string(double(mean(Residual))))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod; less_fast)}');

```



Single-Mode and Onedimensional Function with $x = 20.0$

```

import py.fast_wave.wavefunction.wavefunction_smod

N_max = 100;
x = 20.0;

```

```

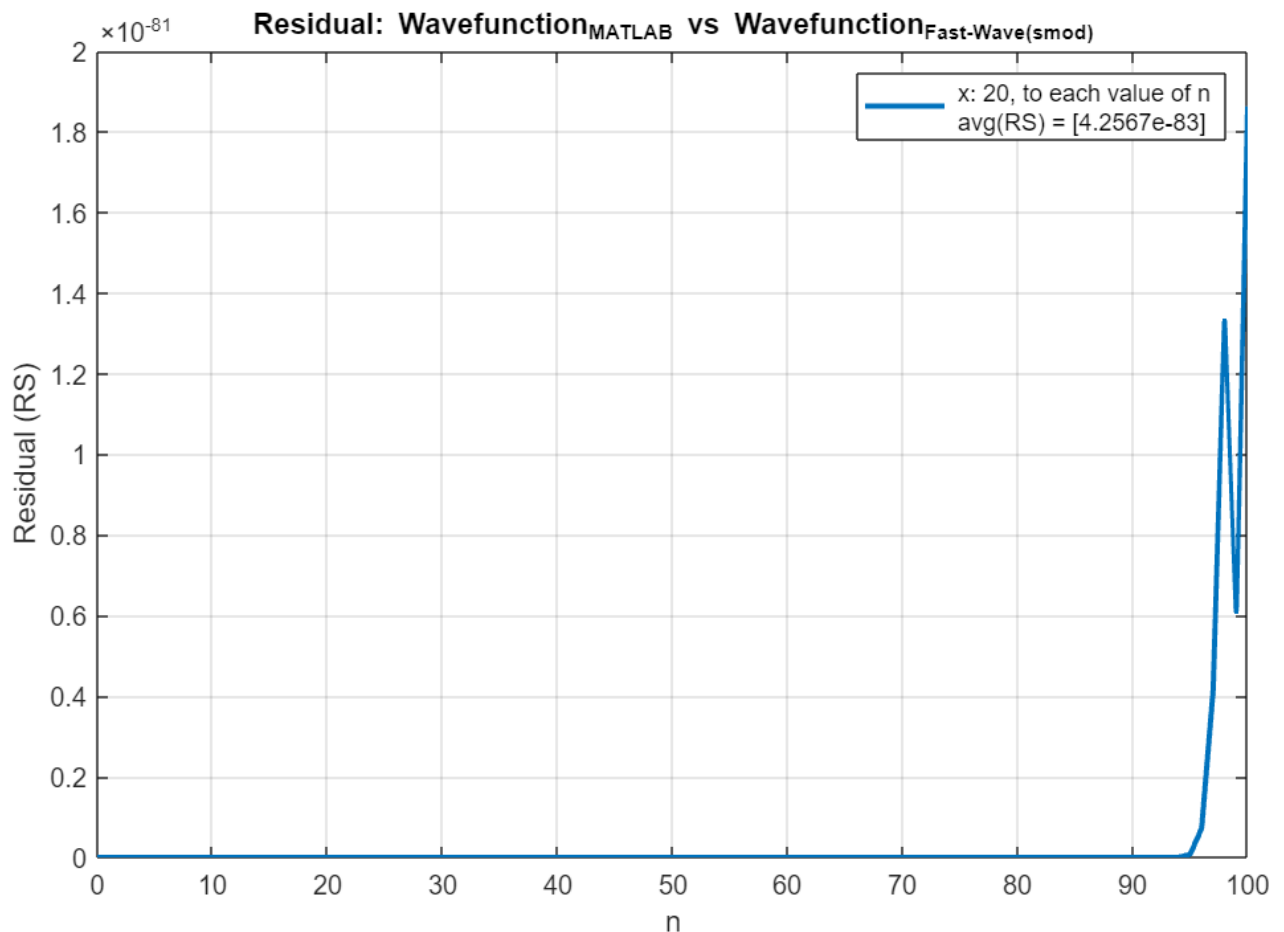
Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -
vpa(wavefunction_smod(uint64(index-1), x)))^2;
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = [' +
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod)}');

```



Single-Mode and Onedimensional Function with $x = 20.0$

```

import py.fast_wave.wavefunction.wavefunction_smod

```

```

N_max = 100;
x = 20.0;

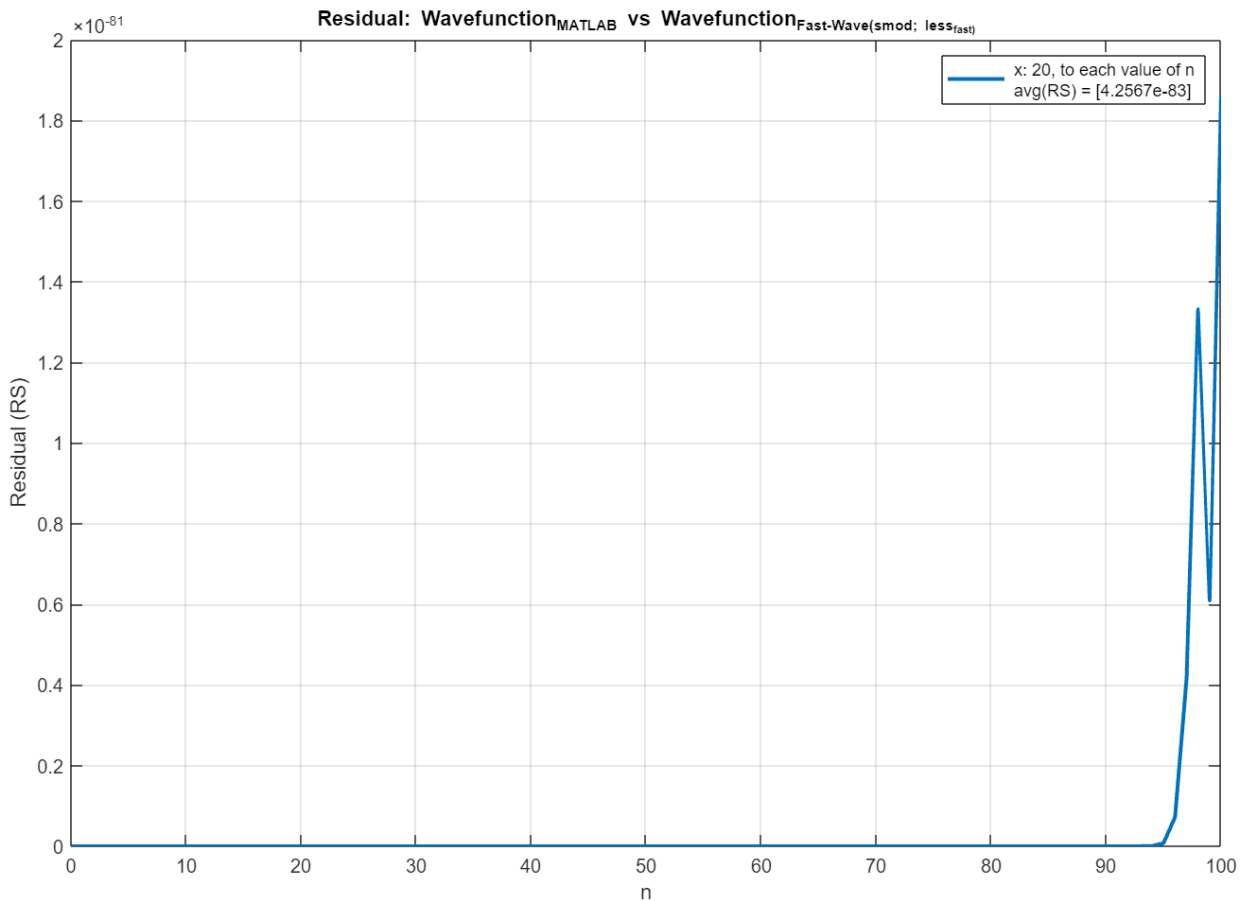
Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = (wavefunction_MATLAB_1(index-1, x, prec) -
vpa(wavefunction_smod(uint64(index-1), x, more_fast=false)))^2;
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: ' + string(x)+' , to each value of n \n avg(RS) = [' +
string(double(mean(Residual))))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smod; less_fast)}');

```



Single-Mode and Multidimensional Function with X: $[(-20) \rightarrow 20; 100]$

```
import py.fast_wave.wavefunction.wavefunction_smmd

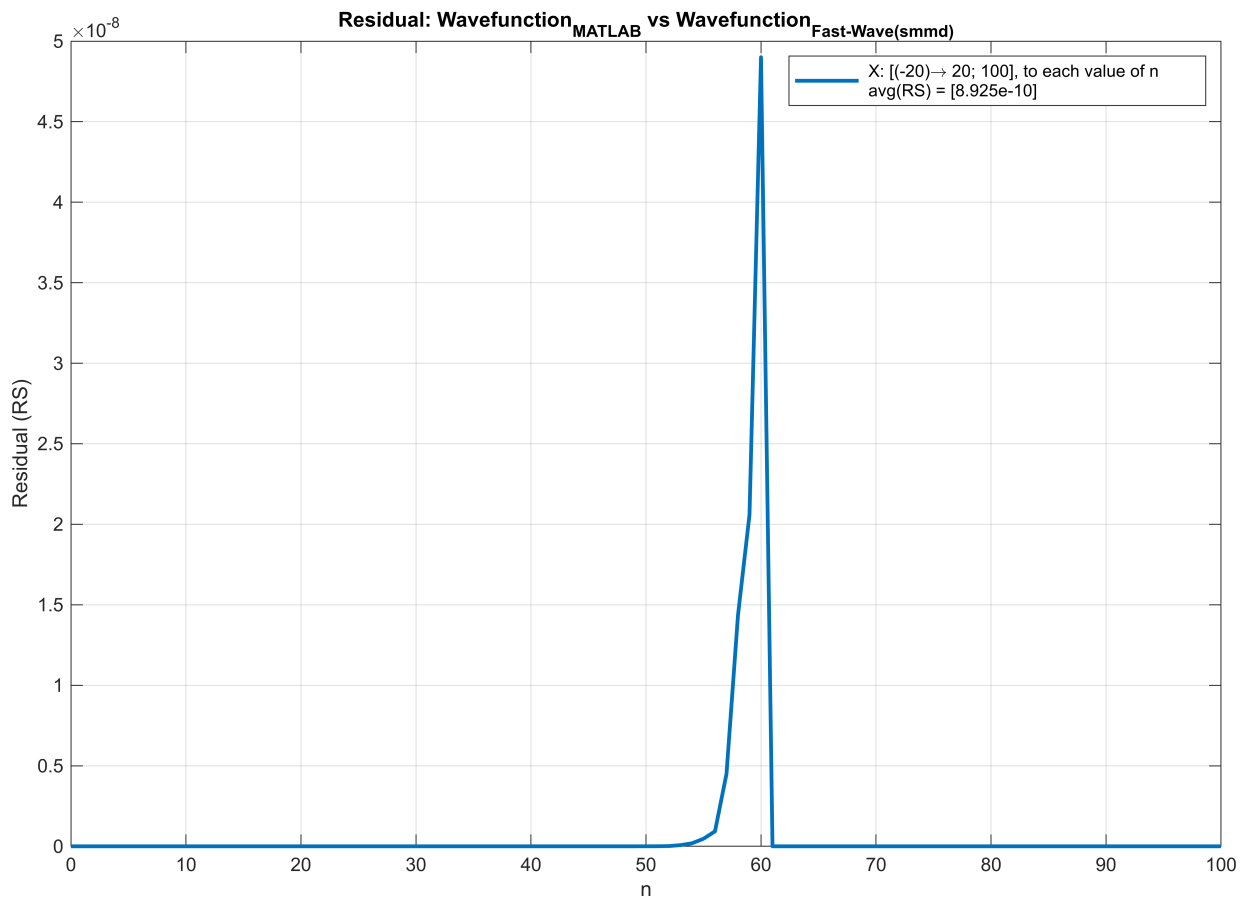
N_max = 100;
x_max = 20.0;
x_min = -20.0;
x_size = 100;
X = linspace(x_max,x_min,x_size);

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = mean((wavefunction_MATLAB_1(index-1, X, prec) -
vpa(double(wavefunction_smmd(uint64(index-1), py.numpy.array(X))))).^2);
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' X:  $[(-20) \rightarrow 20; 100]$ , to each value of n \n avg(RS) =
['+ string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smmd)}');
```

Single-Mode and Multidimensional Less Fast Function with X: $[(-20) \rightarrow 20; 100]$

```
import py.fast_wave.wavefunction.wavefunction_smmd

N_max = 100;
x_max = 20.0;
x_min = -20.0;
x_size = 100;
X = linspace(x_max,x_min,x_size);

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = mean((wavefunction_MATLAB_1(index-1, X,
prec) - vpa(double(wavefunction_smmd(uint64(index-1), py.numpy.array(X),
more_fast=false))))).^2);
end

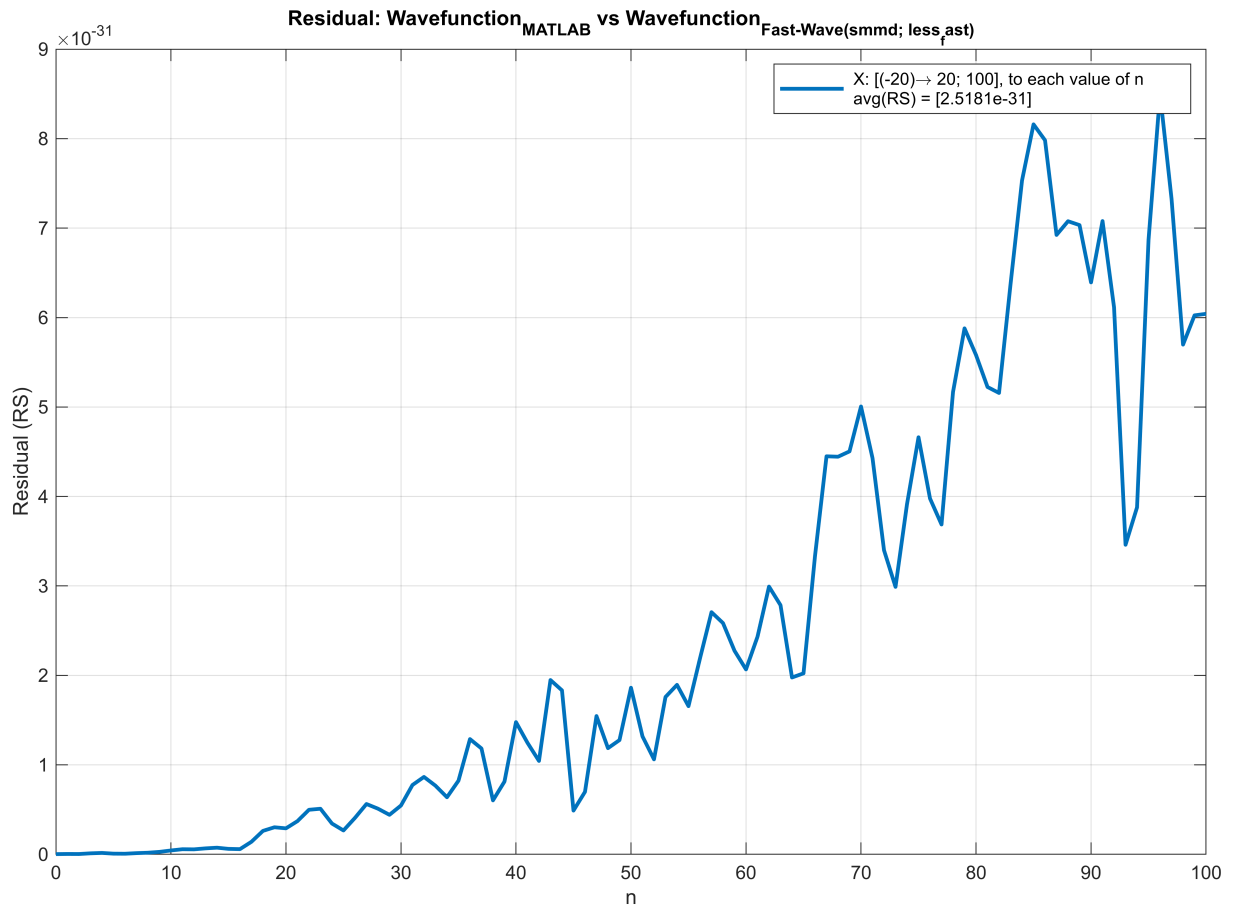
figure('Position', [100, 100, 1200, 800]);
```

```

plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' X: [(-20)\rightarrow 20; 100], to each value of n \n avg(RS) = \n '+ string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(smmd; less_fast)}');

```



Multi-Mode and Onedimensional Function with x: 1.0

```

import py.fast_wave.wavefunction.wavefunction_mmod

N_max = 100;
x = 1.0;

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1

```

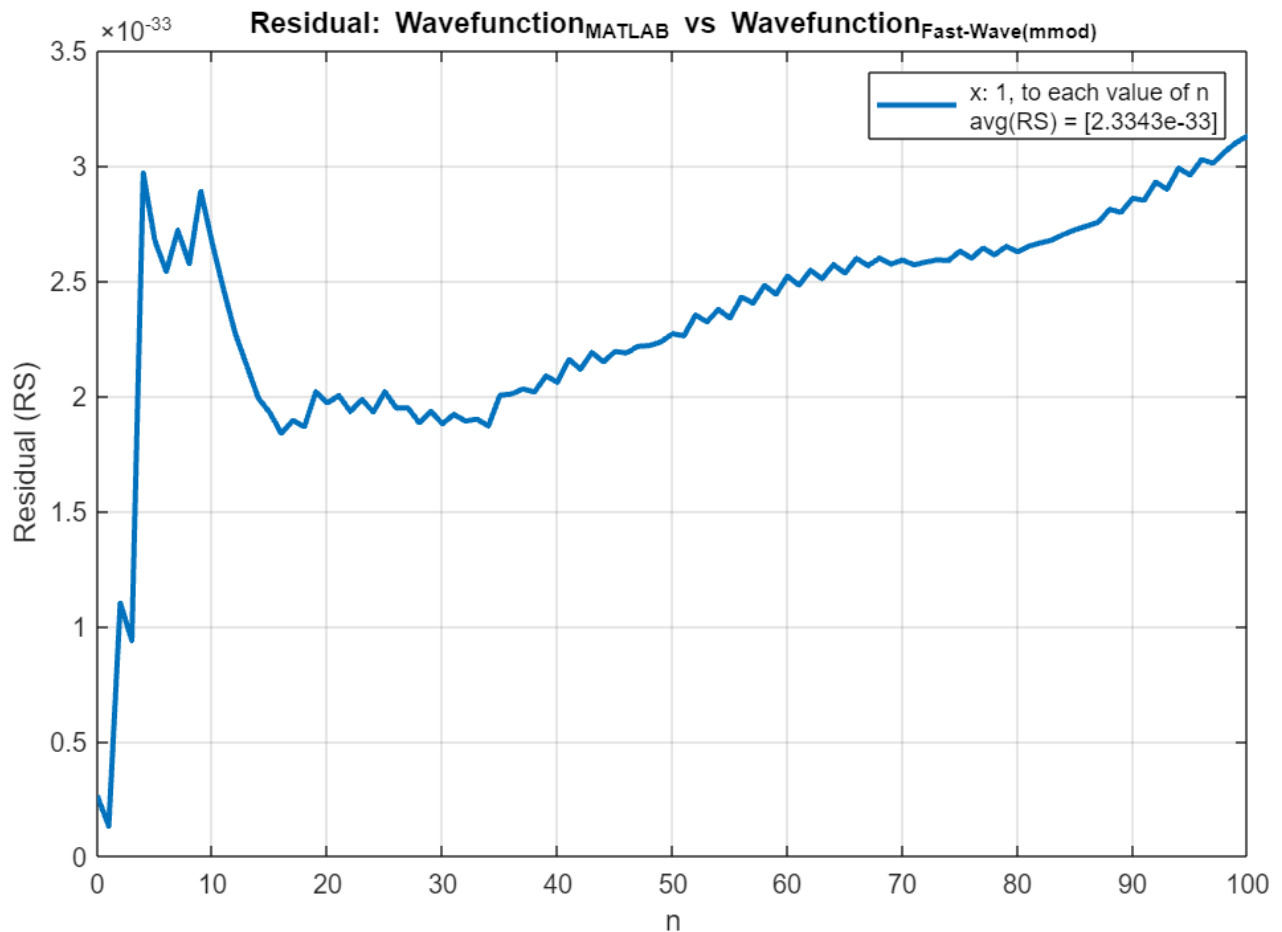
```

Residual(index,:) = mean((wavefunction_MATLAB_3(index-1, x, prec) -
vpa(double(wavefunction_mmod(uint64(index-1), x))))).^2);
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: '+string(x)+' , to each value of n \n avg(RS) = ['+
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(mmod)}');

```



Multi-Mode and Onedimensional Function with $x = 10.0$

```

import py.fast_wave.wavefunction.wavefunction_mmod

N_max = 100;
x = 10.0;

Residual = vpa(zeros(N_max+1, 1));

```

```

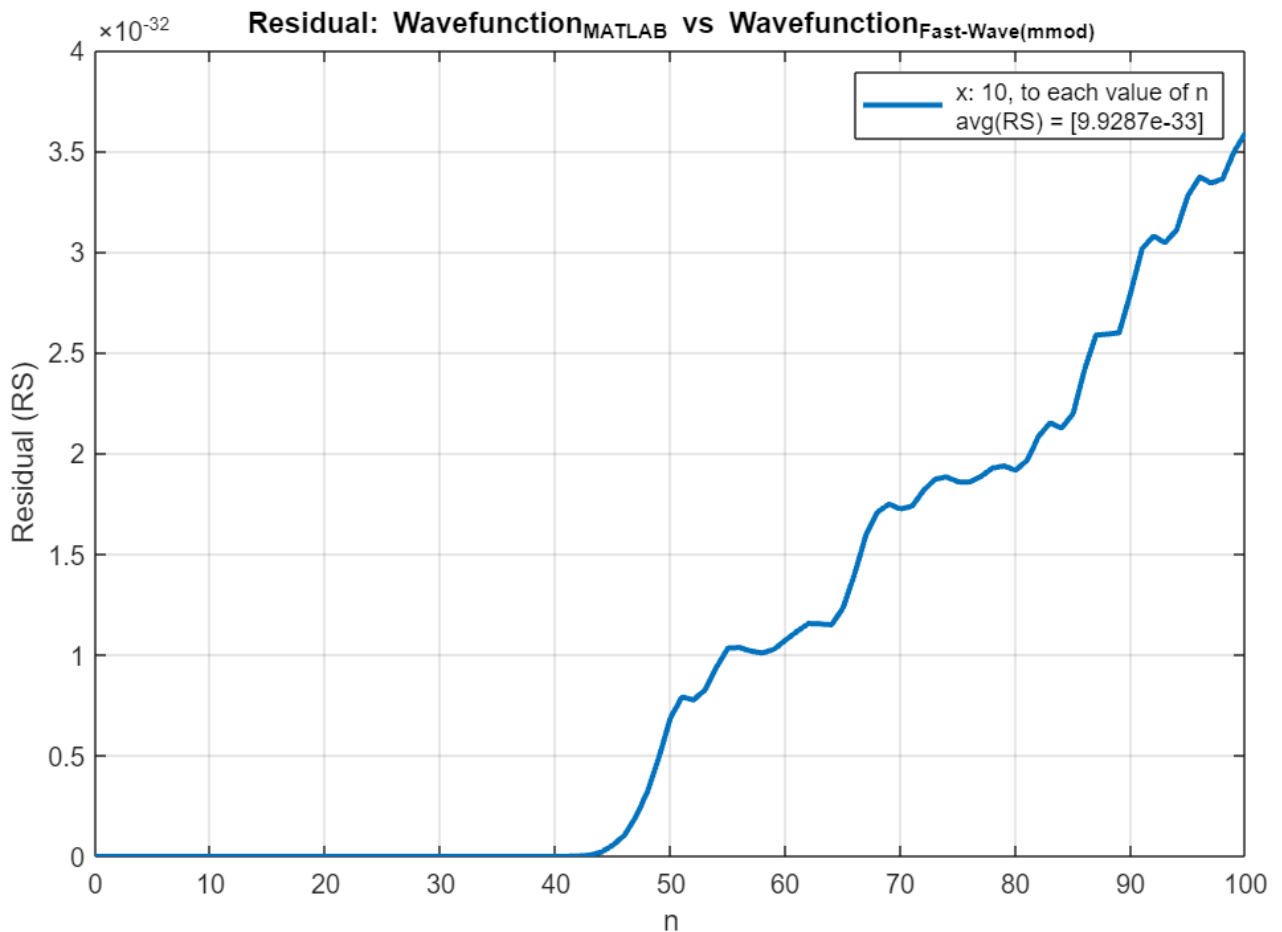
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = mean((wavefunction_MATLAB_3(index-1, x, prec) -
vpa(double(wavefunction_mmod(uint64(index-1), x))))).^2);
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: '+string(x)+' , to each value of n \n avg(RS) = ['+
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(mmod)}');

```



Multi-Mode and Onedimensional Function with $x = 20.0$

```

import py.fast_wave.wavefunction.wavefunction_mmod

N_max = 100;

```

```

x = 20.0;

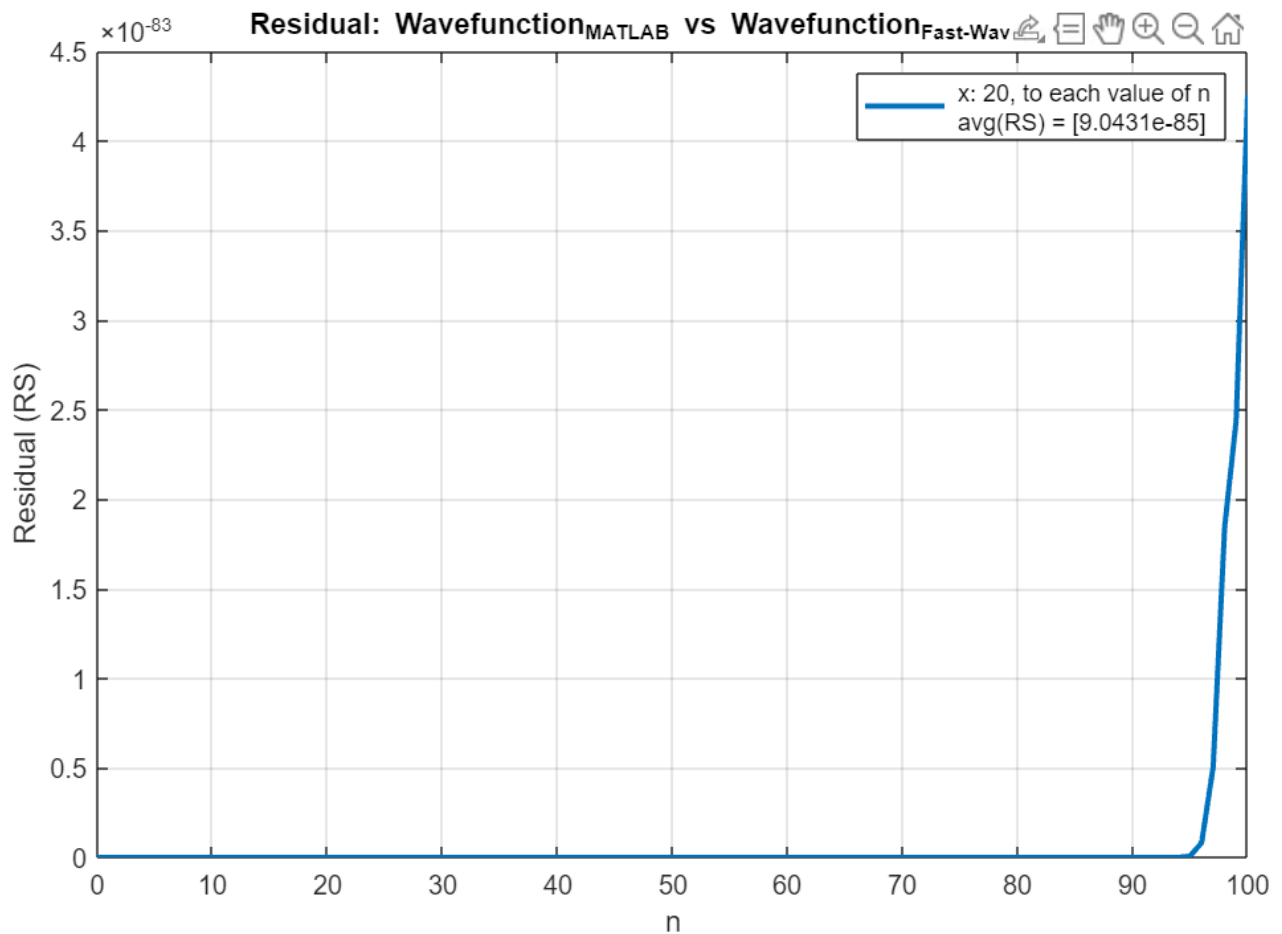
Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual(index,:) = mean((wavefunction_MATLAB_3(index-1, x, prec) -
vpa(double(wavefunction_mmod(uint64(index-1), x))))).^2);
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' x: '+string(x)+' , to each value of n \n avg(RS) = ['+
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(mmod)}');

```



Multi-Mode and Multidimensional Function with X: $[(-20) \rightarrow 20; 100]$

```

import py.fast_wave.wavefunction.wavefunction_mmmd

N_max = 100;
x_max = 20.0;
x_min = -20.0;
x_size = 100;
X = linspace(x_max,x_min,x_size);

Residual = vpa(zeros(N_max+1, 1));
x_axi_plot = linspace(0,N_max,N_max+1);

for index = 1:N_max+1
    Residual_Matrix = ( wavefunction_MATLAB_4(index-1, X, prec) -
vpa(double(wavefunction_mmmd(uint64(index-1), py.numpy.array(X)))) ).^2;
    Residual(index,:) = mean(Residual_Matrix(:));
end

figure('Position', [100, 100, 1200, 800]);
plot(x_axi_plot, Residual, 'LineWidth', 2);
grid on;

xlabel('n');
ylabel('Residual (RS)');
legend(sprintf(' X: [(-20)\rightarrow 20,100], to each value of n \n avg(RS) = ['+
string(double(mean(Residual)))+']'));
title('Residual: Wavefunction_{MATLAB} vs Wavefunction_{Fast-Wave(mmmd)}');

```

