Endsem Lab Assignment

Ground and First Excited States of the Hydrogen Atom

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Contents

1: Octave Code for Problem

```
clc; clear all;

% CONSTANTS
dr = 0.01;
k = -1;
xmin = dr;
xmax = 1.0;

% INITIALIZE THE VECTORS
Xs = xmin:dr:xmax;
N = length(Xs);
P = @(j) 2*k + 1/j;

% INITIALIZE THE TRIDIAGONAL MATRIX
A = zeros(N, N);
for i = 1:N
  A(i, i) = -P(i);
  if i < N
    A(i, i+1) = k;
  endif
  if i > 1
    A(i, i-1) = k;
  endif
endfor

% FIND THE EIGENVALUES AND EIGENVECTORS
[V, D] = eigs(A);
psi0 = V(:, 1);
psi1 = V(:, 2);
e0 = D(1, 1);
e1 = D(2, 2);

psi0 = psi0 / norm(psi0);
psi1 = psi1 / norm(psi1);

% PLOT THE RESULTS
plot(Xs, psi0);
hold on;
plot(Xs, psi1);
title("Ratial wave function r.R(r) for Ground State and First Excited
    State");
xlabel("r");
ylabel("u(r)");
legend(["Ground State"; "First Excited State"]);
hold off;
```

2: Results

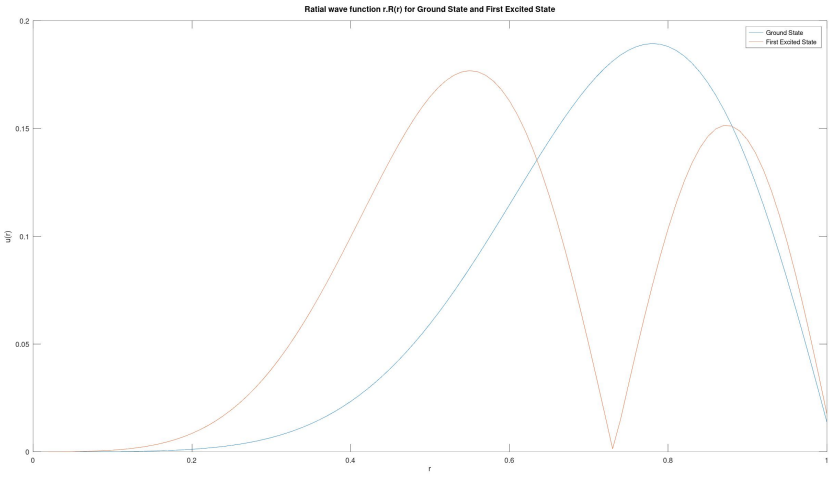

Figure 2.1: Ground State and First Excited State Radial Function of the Hydrogen Atom

2.1 Eigenvalues

The eigenvalue for ground state: 3.9835
The eigenvalue for first excited state: 3.9758
in the normalized units.