Physics 410: Homework 4

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30 November, 2018

Please see `RK4.py` in the `code` folder for the relevant code for this Homework.

Question 1

For E = 1 eV, we can see that our wave function, at least on a linear scale, blows up as x increases. We can see that a similar trend happens at lower x due to the quasi-linear logscale.

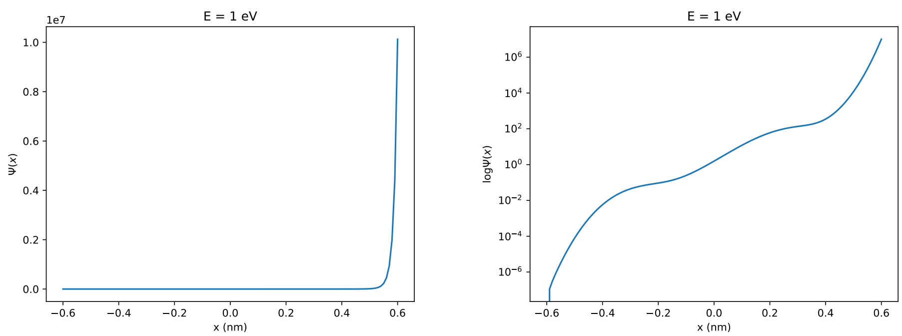


Figure 1: Plot of $\Psi(x)$ fo 1 eV. On the left, we have a linear scale while, on the right, we have a logarithmic scale. Based on these, we can see that, even though the dramatic increase exists, especially for the higher x, we can see that the exponential trend also exists in the lower x.

We would expect, if the 1eV was an energy eigenstate, our solution would not blow up since the *nonphysical* increasing component of the solution would have had a coefficient of zero, leading to only a decreasing component to be the only contributing part. If we were propagating in a classically allowed region, even if we did not have a correct energy eigenstate and our *nonphysical* increasing component had a non-zero contribution at the start, that contribution would have quickly died down.

However, in this case, 1eV is not a correct energy eigenstate nor does it ever enter a classically allowed region (all level under ~ 20 eV is not classically allowed). In this case, our *nonphysical* increasing component of our solution has a non-zero coefficient that stays fully as we propagate in our domain. This leads to the increasing component quickly dominating the solution leading to a "blow up" as x increases.

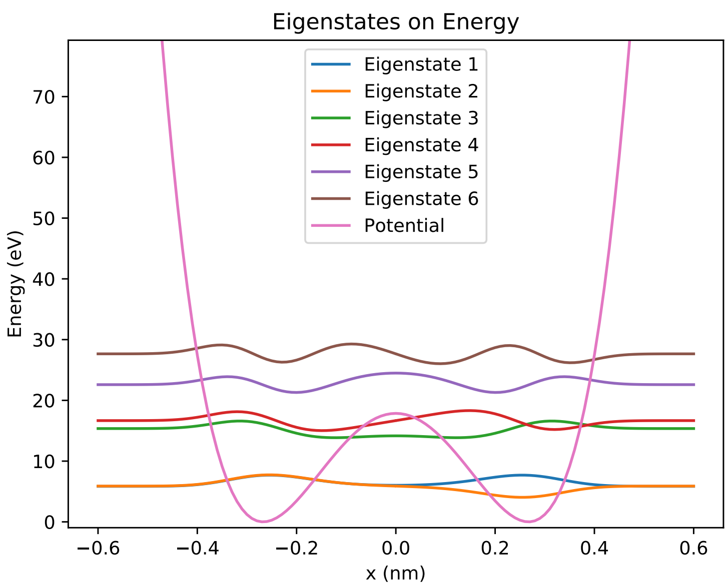
Question 2

For even states, $\Psi'(0) = 0$ since it should be an inflection point. As for odd states, $\Psi(0) = 0$ since we should expect a parity shift at the origin.

Question 3

The 6 lowest energy eigenvalues are: 5.8533 eV, 5.8896 eV, 15.3591 eV, 16.6689 eV, 22.5864 eV, and 27.6564 eV.

Question 4



The first thing that we can note is that even and odd states alternate as solutions, and that the spacings for the eigenstates are increasing. As for the two lowest eigenstates, we can see that they have a double anharmonic potential well, and as such, have a classically' forbidden region in between two classically allowed regions. This, however, is rectified by quantum mechanics with the help of quantum tunneling. They are also paired.