Assignment 2

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1 Question1:

1.1 ODE for Normalized Sheath Potential

The normalized sheath potential $V = \frac{e(\phi_{se}-\phi)}{kT_e}$ with normalized distance $\eta = \frac{x-x_{se}}{\lambda_D}$ for $M_{se} = 1$ is given by

$$\frac{d^2V}{d\eta^2} = \frac{1}{\sqrt{1+2V}} - e^{-V} \tag{1}$$

1.2 Expression for normalized sheath electric field $\frac{dV}{d\eta}$

Expression for normalized sheath electric field $\frac{dV}{d\eta}$ for $\frac{dV}{d\eta} = \epsilon$ at $\eta = 0$ is given by

$$\frac{dV}{d\eta} = \sqrt{\epsilon^2 + 2(\sqrt{1+2V} + e^{-v} - 2)} \tag{2}$$

2 Question 2

2.1 Bohm Condition

The form it takes in the Bohm ($V \ll 1$) case is:

$$\frac{dV}{d\eta} = \epsilon \Rightarrow V(\eta) = \epsilon\eta \tag{3}$$

where ϵ is $\frac{dV}{d\eta}$ at $\eta = 0$

2.2 Child-Langmuir Limits

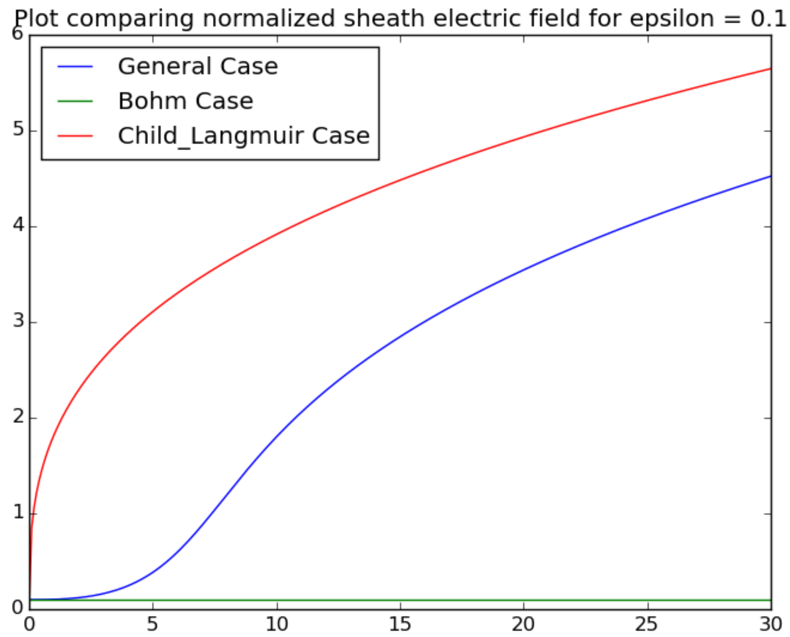
The form it takes in the Child-Langmuir ($V \gg 1$) case is:

$$V(\eta) = \frac{3^{\frac{4}{3}}}{2^{\frac{5}{3}}}\eta^{\frac{4}{3}} \Rightarrow \frac{dV}{d\eta} = 6^{\frac{1}{3}}\eta^{\frac{1}{3}} \tag{4}$$

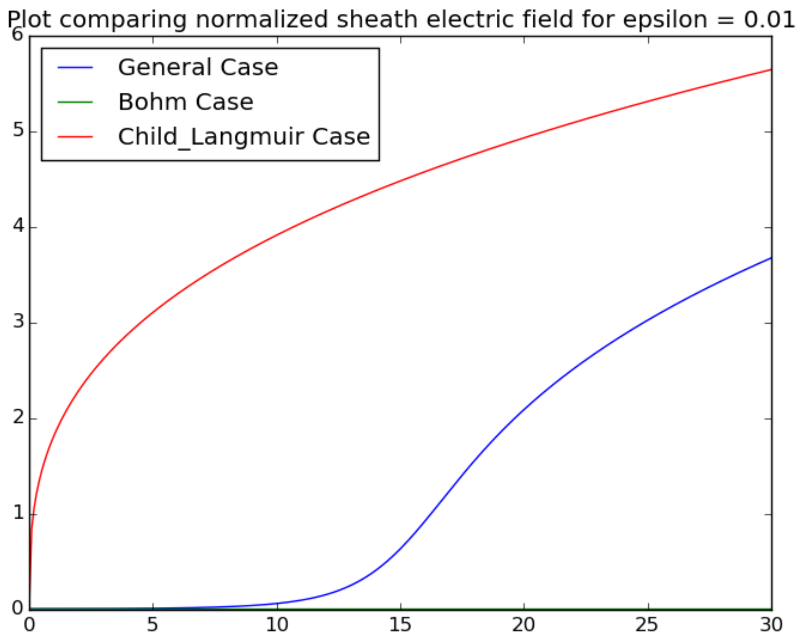
3 Question 3

3.1 Normalized electric Field

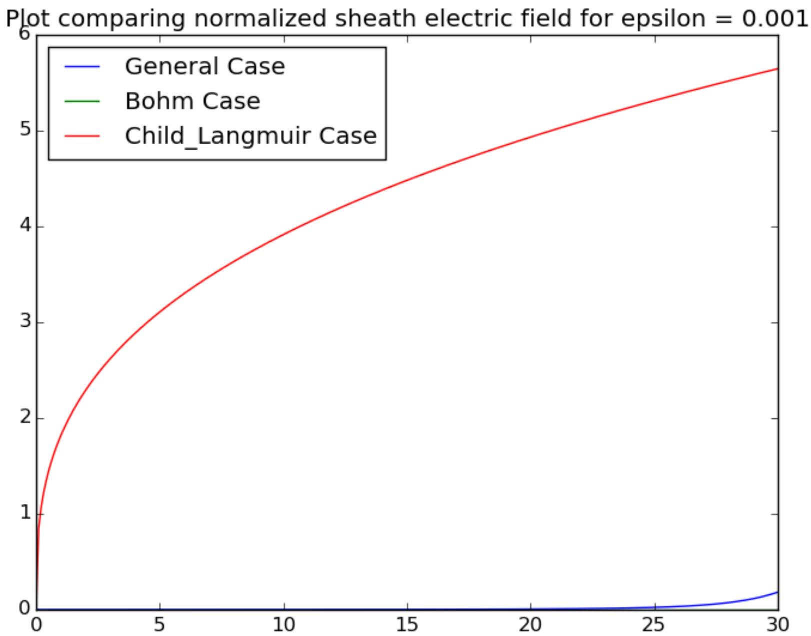
Plots comparing the RHS for normalized electric field for the three cases:



Plot comparing normalized sheath electric field for epsilon = 0.1
General Case
Bohm Case
Child_Langmuir Case
0
1
2
3
4
5
6
0
5
10
15
20
25
30

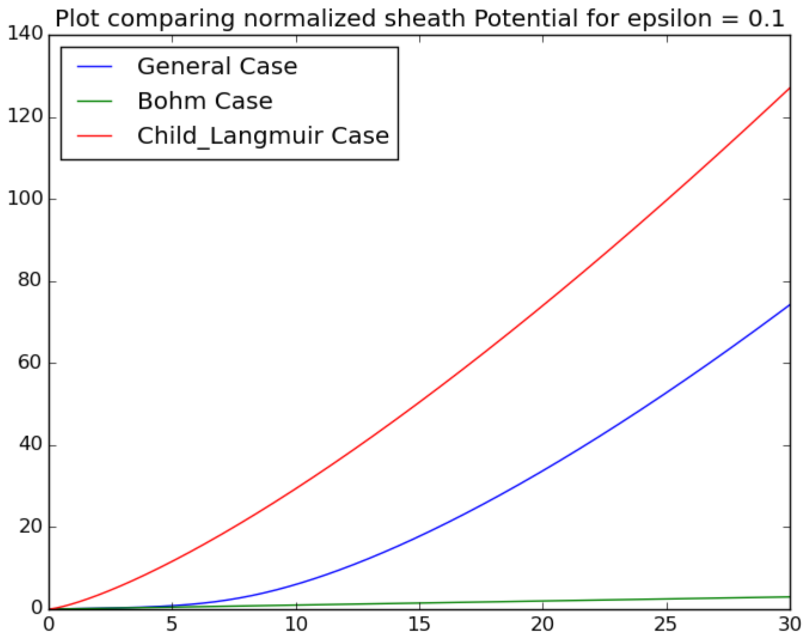


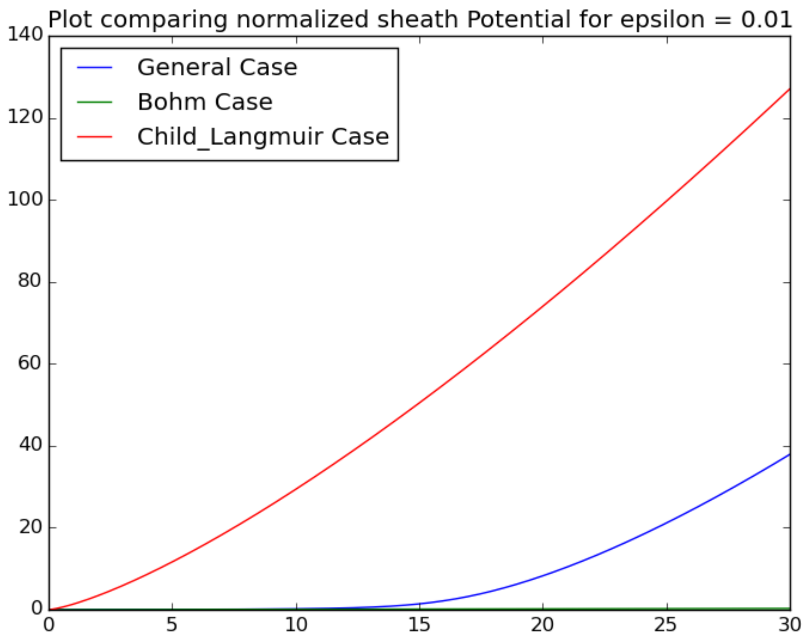
Plot comparing normalized sheath electric field for epsilon = 0.01
General Case
Bohm Case
Child_Langmuir Case
0
1
2
3
4
5
6
0
5
10
15
20
25
30

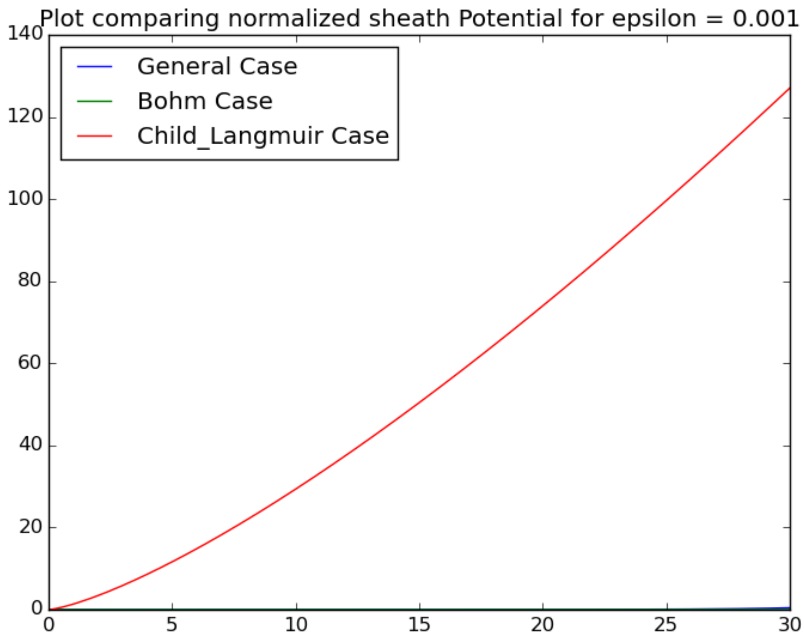


3.2 Normalized Potential

Plots comparing the RHS for normalized Potential for the three cases:


Plot comparing normalized sheath Potential for epsilon = 0.1
General Case
Bohm Case
Child_Langmuir Case
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30


Plot comparing normalized sheath Potential for epsilon = 0.01
General Case
Bohm Case
Child_Langmuir Case
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30



4 Question 4

The exact solution derived for wall potential is $V_w = \frac{1}{2}ln(\frac{m_i}{2\pi m_e}) \approx 2.83$ (Refer Code)

- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.100000$ is 7.815631
- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.010000$ is 16.633267
- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.001000$ is 34.368737
- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.000100$ is 71.671672
- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.000010$ is 151.615162
- Sheath thickness normalized with debye length to reach wall potential for $\epsilon = 0.000001$ is 323.832383

5 Question 5

The normalized electric field is given for different cases of ϵ are

- The normalized electric field for $\epsilon = 0.100000$ is 1.140026
- normalized electric field for $\epsilon = 0.010000$ is 1.135212
- The normalized electric field for $\epsilon = 0.001000$ is 1.159439
- The normalized electric field for $\epsilon = 0.000100$ is 1.154175
- The normalized electric field for $\epsilon = 0.000010$ is 1.146671
- The normalized electric field for $\epsilon = 0.000001$ is 1.159135

6 Question 6

(Refer Code)

- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 1.000000
- The thickness of sheath for a neutral wall with epsilon = 0.100000 and electrode potential = 1.000000 is 0.140000
- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 10.000000
- The thickness of sheath for a neutral wall with epsilon = 0.100000 and electrode potential = 1.000000 is 0.170000
- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 100.000000
- The thickness of sheath for a neutral wall with epsilon = 0.100000 and electrode potential = 1.000000 is 0.210000
- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 1.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.140000
- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 10.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.170000

- Child Langmuir starts at eta = 0.080000 for epsilon = 0.010000 for V = 100.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.210000
- Child Langmuir starts at eta = 0.120000 for epsilon = 0.001000 for V = 1.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.170000
- Child Langmuir starts at eta = 0.120000 for epsilon = 0.001000 for V = 10.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.210000
- Child Langmuir starts at eta = 0.120000 for epsilon = 0.001000 for V = 100.000000
- The thickness of sheath for a neutral wall with epsilon = 0.010000 and electrode potential = 1.000000 is 0.240000