Rydberg Atom Dipole Dipole Interaction

Variation of Rydberg atom dipole dipole interaction energy with respect to the sepration between the two atoms:

$$V_{dd} = \frac{K}{R^3}\left(\vec{d_1}.\vec{d_2} - 3(\vec{d_1}.\hat{R})(\hat{R}.\vec{d_2})\right)$$

Where $K = \frac{1}{4\pi\epsilon_0}$, $d_i = -n^2 e a_0$ dipole moment of atom i (a_0: Bohr radius, n: Rydberg level), and R is the sepration between two atoms.

In [4]:

```
import numpy as np
from numpy import cos, pi
from matplotlib import pyplot as plt
```

In [5]:

```
k = 9 * (10**9)
a0 = 1  #0.529 * 10**(-10) #Bohr radius
e = 1  #9.1 * 10**(-19) #Electron charge
n = 100 # Rydberg level

#Dipole moment
d = -(n**2)*e*a0


print('\nThe value of dipole moment :',d)
```

```
The value of dipole moment : -10000
```

In [6]:

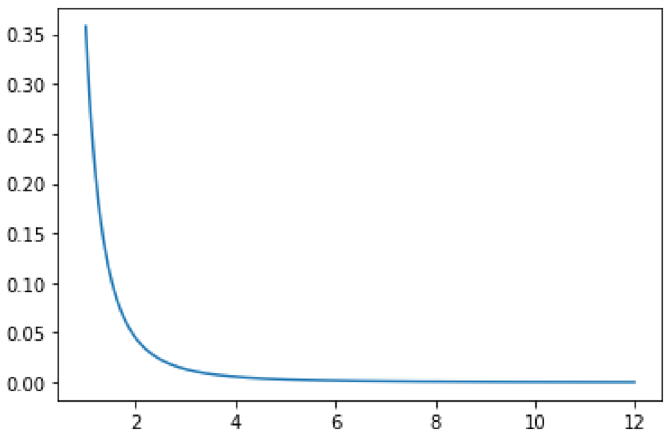
```
#Sepration between atoms
R = np.arange(1,12,0.01)

alpha = [0,30,45,60,90] #angle between two dipoles
theta = 0 #angle between the d1 and R

V = [0]*len(alpha)

for i in range(len(alpha)):
    V[i] = 10**(-18)*(k/R**3)*((d**2)*cos(alpha[i])
                            - 3*(d**2)*cos(theta)*cos(theta - alpha[i]))
```

In [7]:

```
V0 = 10**(-18)*(k/R**3)*((d**2)*cos(0)
                            - 3*(d**2)*cos(90)*cos(90))

plt.plot(R,V0)
```

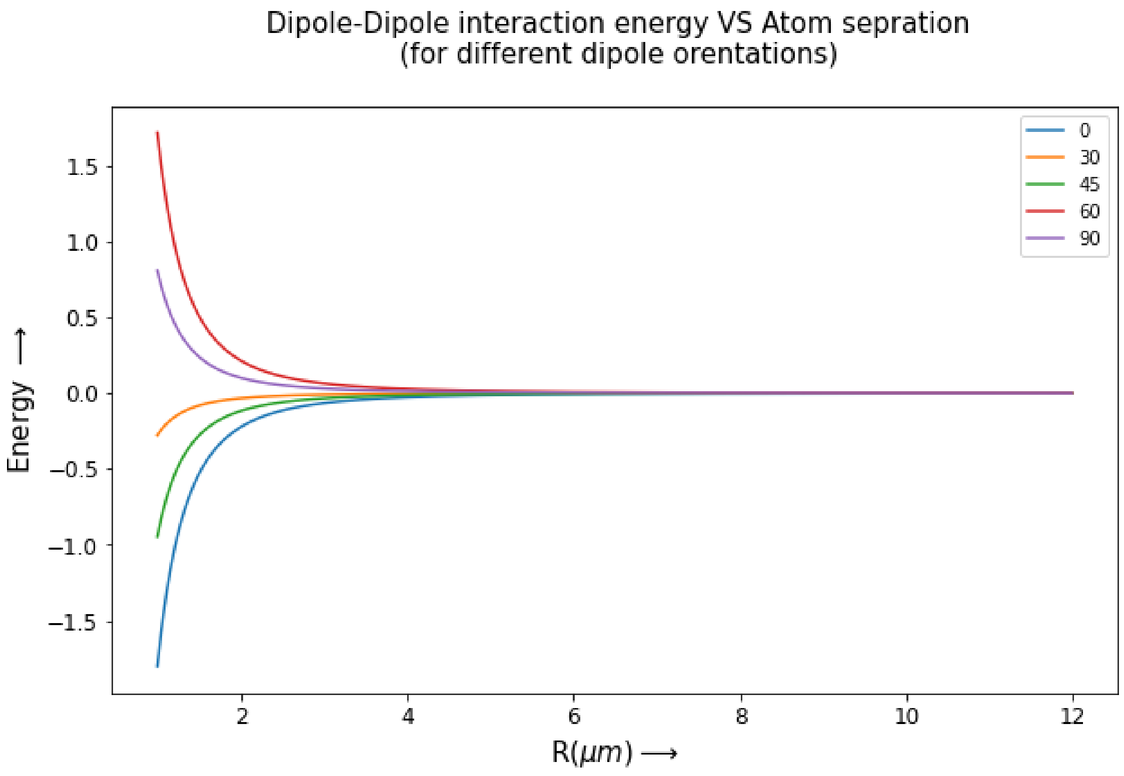
Out[7]:

```
[<matplotlib.lines.Line2D at 0x748decca00>]
```



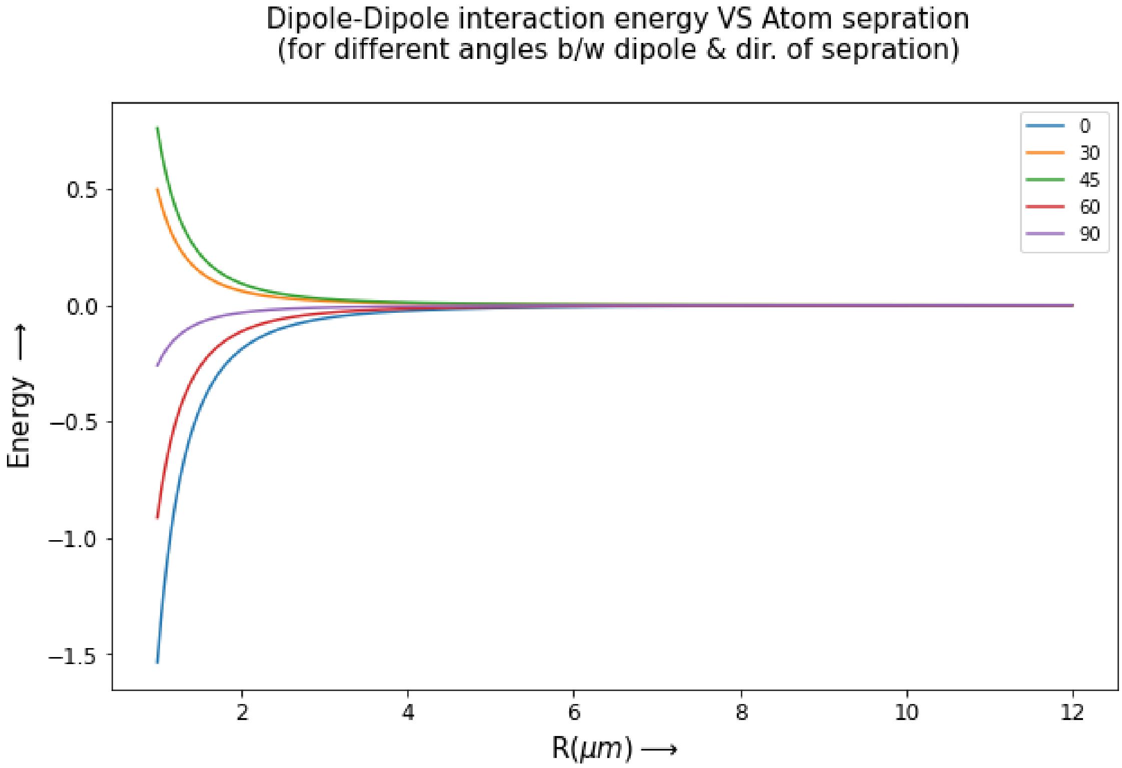
In [8]:

```
#%matplotlib notebook
fig = plt.figure(figsize=(10,6))

for i in range(len(alpha)):
    plt.plot(R,V[i])

plt.xticks(size=12)
plt.yticks(size=12)
plt.title('\n\n Dipole-Dipole interaction energy VS Atom sepration\n (for different dip
plt.xlabel(r'R$(\mu m) \longrightarrow$', size=15)
plt.ylabel(r'Energy $\longrightarrow$', size=15)
plt.legend(['0','30','45','60','90'])
plt.show()
```



In [9]:

```
#%matplotlib notebook
theta = [0,30,45,60,90] #angle between the d1 and R

alpha = 56 #angle between two dipoles

V1 = [0]*len(theta)

for i in range(len(theta)):
    V1[i] = 10**(-18)*(k/R**3)*((d**2)*cos(alpha)
                              - 3*(d**2)*cos(theta[i])*cos(theta[i] - alpha))

fig = plt.figure(figsize=(10,6))

for i in range(5):
    plt.plot(R,V1[i])

plt.xticks(size=12)
plt.yticks(size=12)
plt.title('\n\n Dipole-Dipole interaction energy VS Atom sepration\n (for different ang
plt.xlabel(r'R$(\mu m) \longrightarrow$', size=15)
plt.ylabel(r'Energy $\longrightarrow$', size=15)
plt.legend(['0','30','45','60','90'])
plt.show()
```



Dipole-Dipole interaction energy VS Atom sepration
(for different angles b/w dipole & dir. of sepration)
0
30
45
60
90
0.5
0.0
−0.5
−1.0
−1.5
Energy ⟶
2
4
6
8
10
12
R(μm) ⟶