Computational Methods in Physics

Electric Fields and potentials

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0.1 Introduction

The aim of the program is to simulate electric field and potential in different situations. Tho options are three (since now): two charges, two conducotrs, two spheres.

0.2 Physics concepts

0.2.1 Charges

For a charge Q, potential and electric fields are basically

$$V = \frac{Q}{4\pi\epsilon_0 \cdot r} \qquad E = \frac{Q}{4\pi\epsilon_0 \cdot r^2} \tag{1}$$

where **r** is the distance from the origin of an axis system **Oxy** or **Oxyz**.

Considering that potential and electric field are additive, V^{tot} and E^{tot} are basically the sum of the ones generated by each charge in the space we are considering.

The plots show what we attend for a configuration where Q1=10 C, Q2=-10 C, r1=(1.5,2) r2=(2,2).

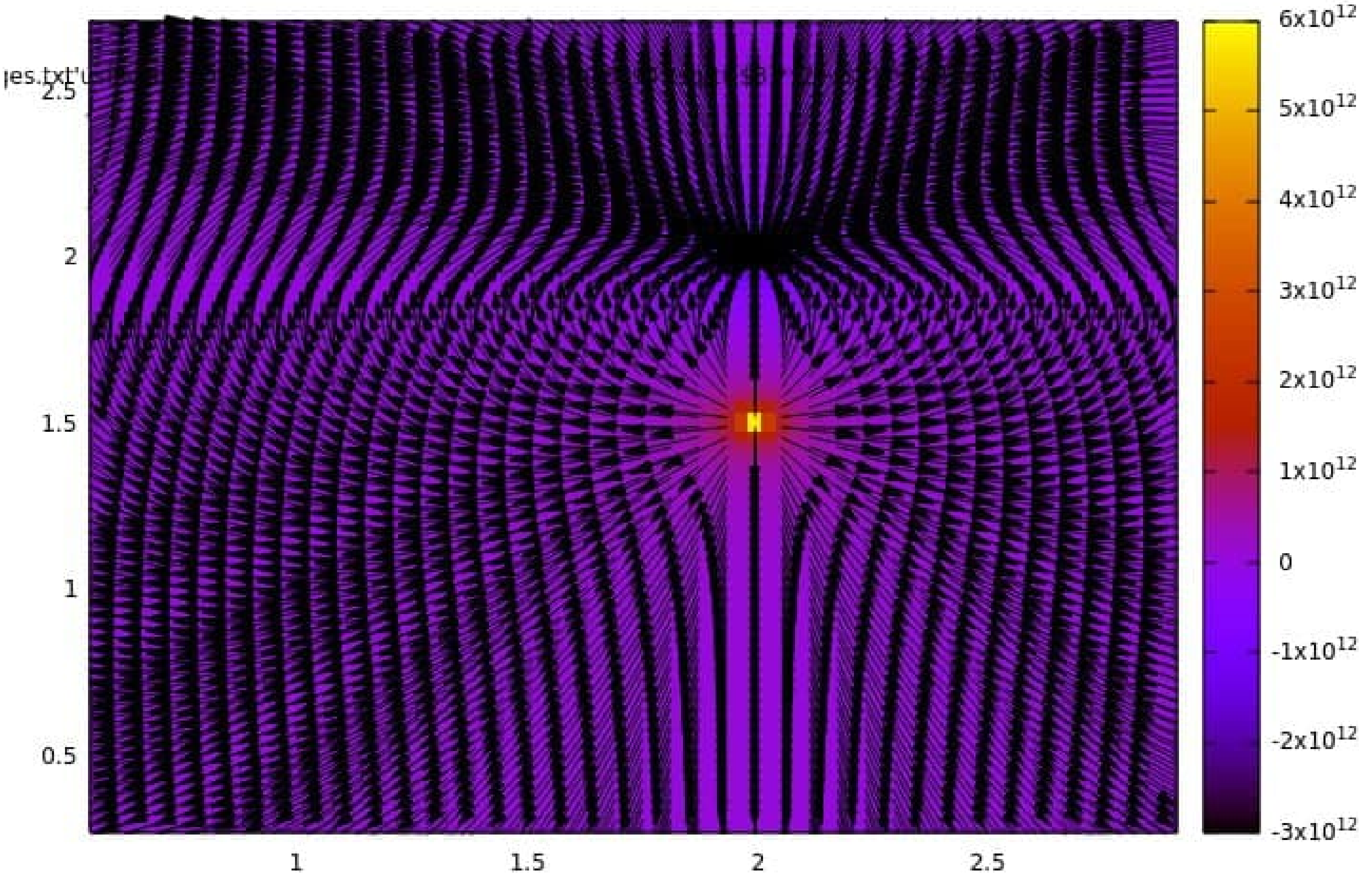

Figure 1: Charges potential and electric field

0.2.2 Conductors

For conductors, the situation is similar to the previous one. These object are characterized by the fact that E=0 inside them.

According to Gauss theorem, for a sphere of radius R and total charge Q, we thus obtain

$$E = \begin{cases} \frac{Q}{4\pi\epsilon_0 \cdot r^2} & r \leq R \\ 0 & r > R \end{cases}$$

and, for the potential:

$$V = \begin{cases} \frac{Q}{4\pi\epsilon_0 \cdot R} & r \leq R \\ \frac{Q}{4\pi\epsilon_0 \cdot r^2} & r > R \end{cases}$$

The latter can be demonstrated through the Poisson's theorem, as explained in section [0.2.3].

As for charges, potential and electric field are additive, so the E^{tot} and V^{tot} are the sum of the contributes of each conductor.

0.2.3 Spheres

The situation regarding this case is a little more complicated. According to Poisson's theorem,

$$E = -\nabla V \qquad \nabla V = -\frac{\rho}{\epsilon_0} \tag{2}$$

What we have to do, is basically finding a way to compute the potential. Then, by changing its sign and derivating it, we can find the electric field.

In the 2D case, we have to

- create a (x,y) grid;
- set the charge distribution;
- set the border conditions (in my case, border is set to zero);
- after setting a convergence threshold, we use Gauss-Seidel method and compute V.
- by deriving -V, we obtain E=(Ex,Ey).

3D case should be similar, a bit more complicated to program, but similar.

Following these steps, by creating two spheres of centers C1=(4,2) and C2=(7,7),rays r1=1 ua and r2=1 ua, charges $\rho_1 = 60\frac{C}{ua^3}$ and $\rho_2 = -60\frac{C}{ua^3}$, we obtain

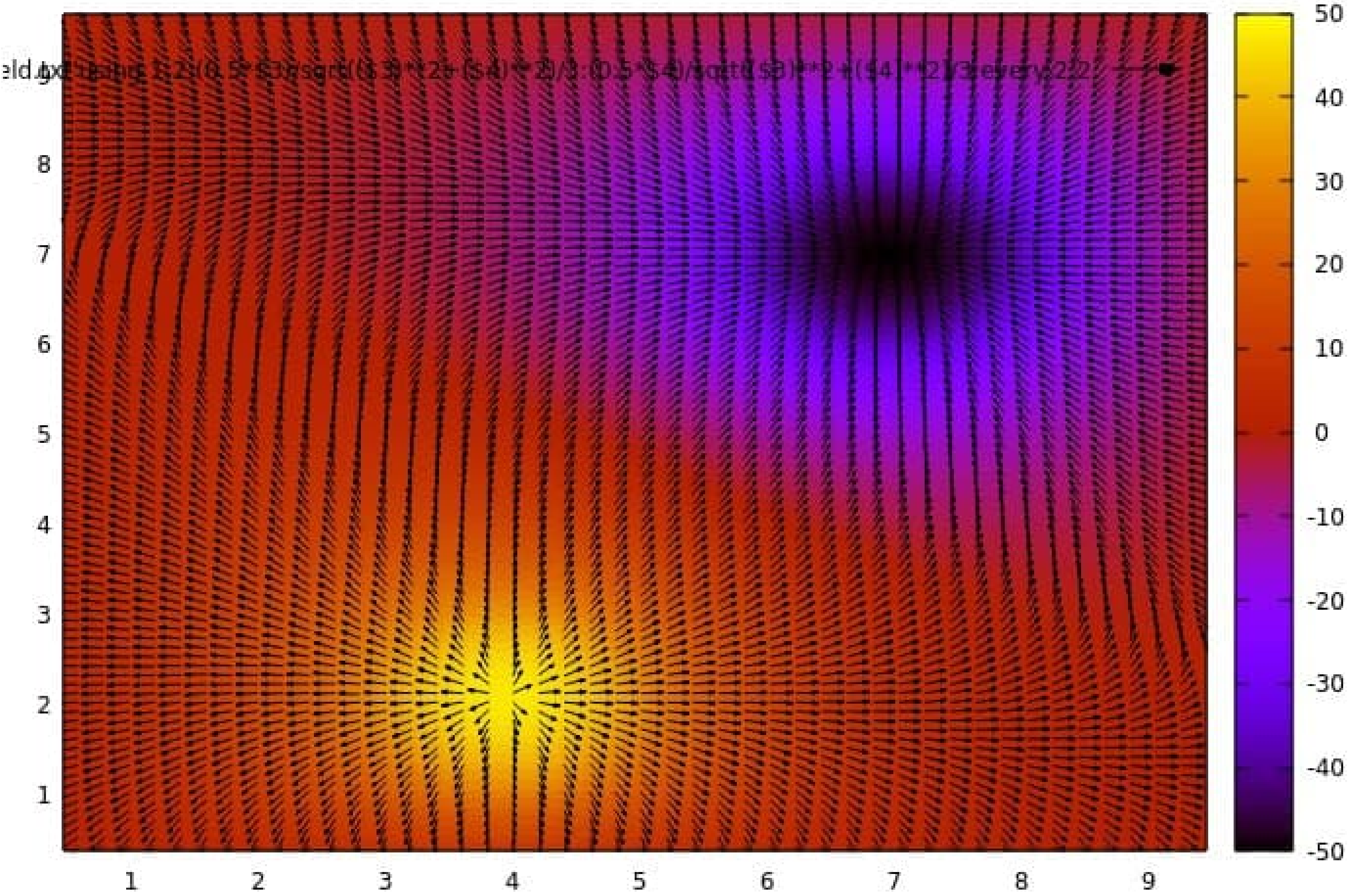

Figure 2: Spheres potential and electric field