Computational Methods in Physics

Electric Fields and potentials
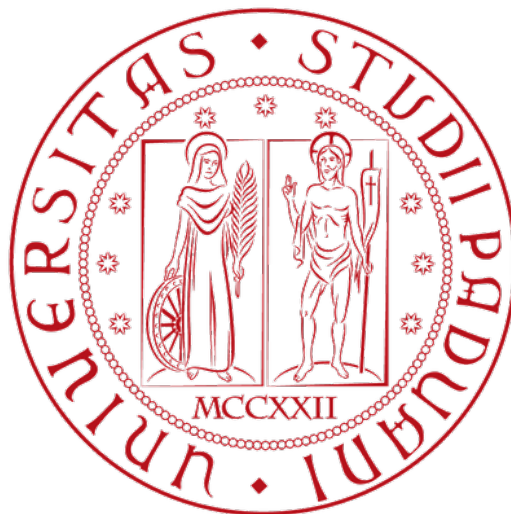
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0.1 Introduction

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

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

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=, Q2=, r1=() r2=().
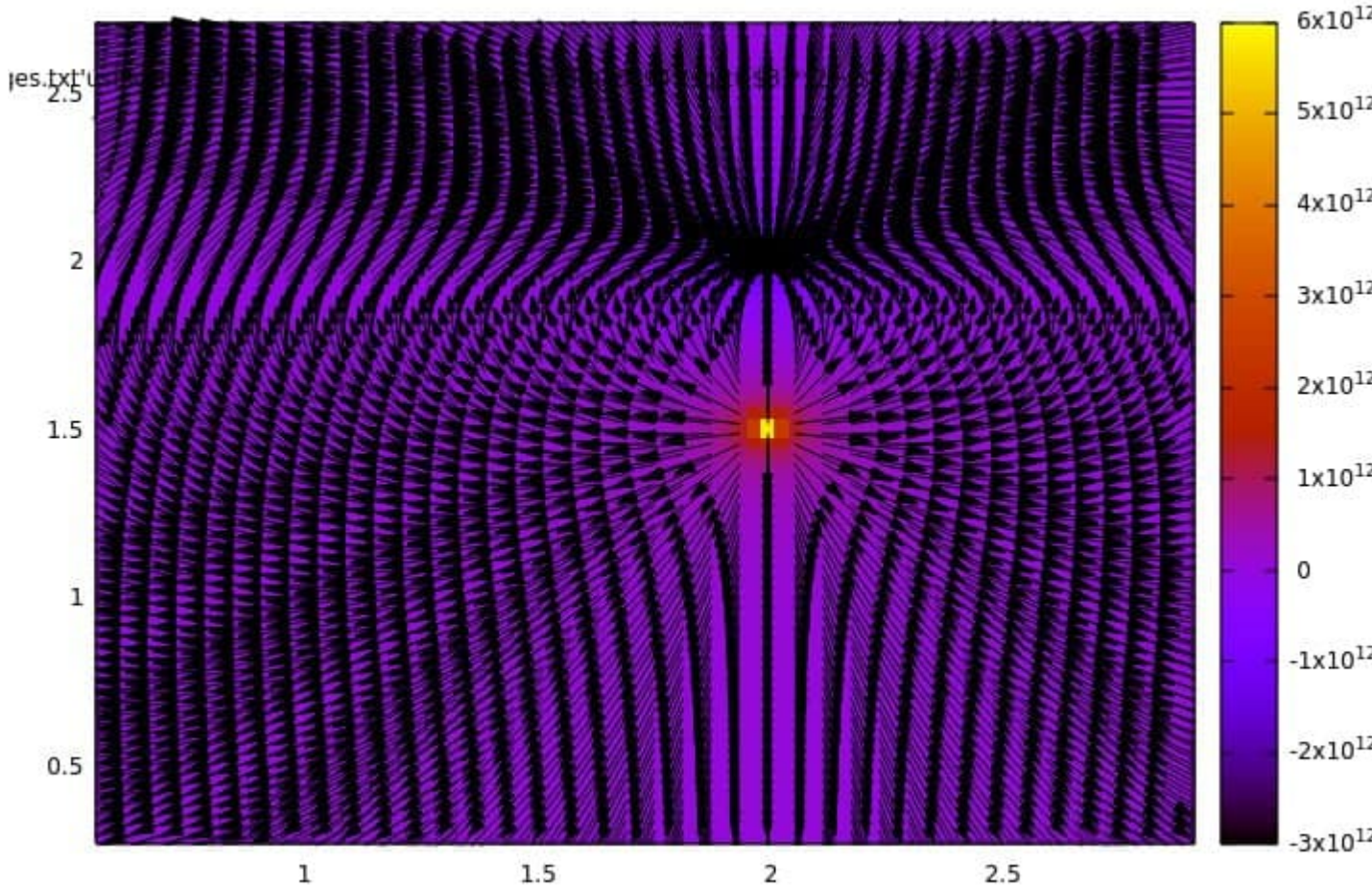

Figure 1: Caption

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,

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

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.

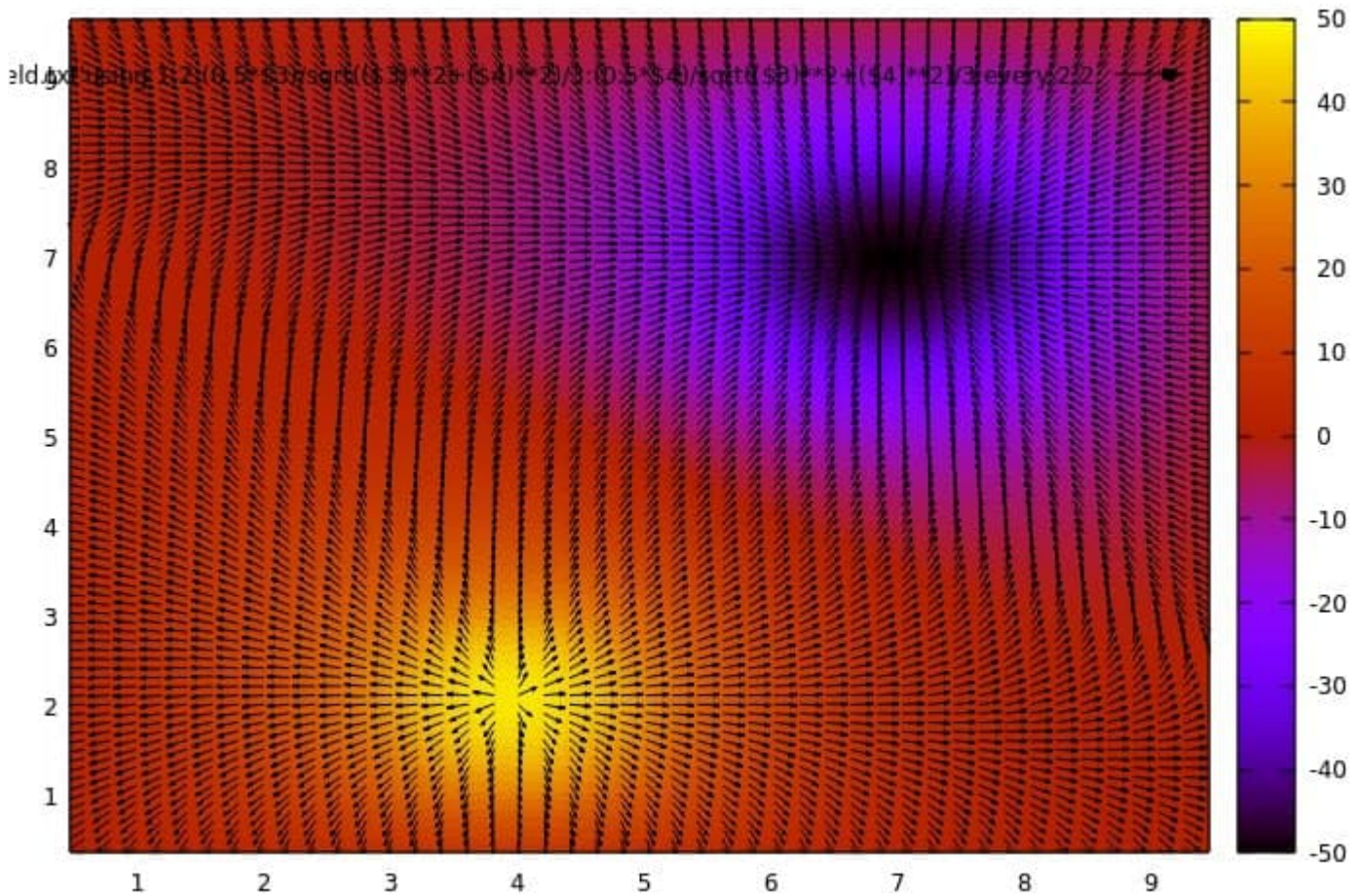Following these steps, by creating two spheres of centers C1=() and C2=(),rays r1=() and r2(), charges $\rho_1 =$ and $\rho_2 =$, we obtain

Figure 2: Spheres potential and electric field