Differences between SI and Gaussian units

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1 SI units

- Coulumb is a derived unit
- base unit involving charge is ampere (for current)
- Force/ meter on one wire when two parallel wires separated by 1 m carrying 1A current and force exerted =2 $\cdot 10^{-7}$
- Coulumb = 1 A$\cdot$ s
- By using Coulumb's law, let $q_1 = q_2 = 1C$ and r=1m, so our F= $9{\cdot}10^9$N [1]
- $\therefore$ we define k=$9{\cdot}10^9 Nm^2/C^2$=$1/4\pi\epsilon_0$ [2]
- $\because$ we defined current via the Lorentz force, the Coulumb force between two charges ends up being a number we just have to accept. We can only have nice numbers in one case or another, not both.
- $\therefore$ the SI system gives preference to Lorentz force $\because$ in historical experiments, galvanometer measures ampere much easier to measure than F exerted by point charges .

2 Gaussian units

- Gaussian unit of charge =esu $\rightarrow$ very different from SI Coulumb
- esu is defined via the Coulumb force
- here, we define k=1 (dimensionless)
- $\therefore$ the Lorentz force involves a factor of c^2

3 Main differences between the systems

- units of $k_{Gaussian}$ is dimensionless

[1] $9{\cdot}10^9 = c^2/10^7$
[2] $\epsilon_0 = 8.85 \cdot 10^{-12} A^2 s^4 kg^{-1} m^{-3}$

- this allows us to solve for esu in terms of base units

$$F = k \cdot \frac{qq}{r^2} \qquad [dynes] = [dimensionless] \cdot [\frac{esu^2}{cm^2}]$$

$$\therefore esu = \sqrt{dynes \cdot cm^2} = \sqrt{g \cdot cm^3 \cdot s^{-2}} \qquad [3]$$

- $\therefore$ esu is not a fundamanetal unit ,whereas A is a fundamental unit in SI.

Three main difference between SI and Gaussian (least important $\rightarrow$ most important)

1. cm-gram-second only differ with SI with powers of 10
2. Gaussian based on Coulumb's law SI based on Lorentz forces
3. $k_{gaussian}$ dimensionless ;k_{SI} is dimensionful
   $\therefore$ can express esu in terms of other gaussian base units.

4 Three units versus four

- $\because$ there is less base units in Gaussian, doing dimensional analysis in gaussian gives us less insight into stuff.

[3] dynes=$g \cdot cm/s^2$