Can there be a non-zero electric field at an isolated position (i.e., a single point) in space even if there is no electric charge there? How could that be possible? Can there be a charge at an isolated position in space where the field is zero? Discuss thoroughly.

Field at a point vs charge at a point

There can not be an electric field without an electric charge as the field is created by the charge. Same thing with the opposite, no field = no charge.

A field represents a possible/prospective/latent/undeveloped entity

A non-zero electric field can be at an isolated position if the position itself has no type of particle there. An electric charge cannot exist without some type of mass for the electric field to apply an electric force to. Using the proton example from the notes, **if the proton was not there, but the ball of positive electric force was, there would be a non-zero electric field without an electric charge.** However, there cannot be an electric charge existing without an electric field, because an electric field is the reason there is an electric charge, and without that there in no charge.

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The electric field is created by the charges, not by the exact point. **It is possible for there to be no electric charge and a non-zero electric field at the location, there will just not be an electric force applied at that location.** Electric forces act on charges and cannot exist in a non-charged location. **It would be possible for there to be a charge at an isolated position in space where the field is zero**. Like charges will repel each other at an equal magnitude therefore their vectors would cancel out so **the force at the point between the two like charges would be zero and that location would have a field value of zero**.

Warning: the one word you can't use is "potential"

Yes, it is possible to have an electric field at an isolated position in the middle of space. There cannot be an electric force at that location without an electric charge. **An electric field is simply the potential for an electric force.**

There can be a charge where the field is zero. If an area has no potential for an electric charge then there cannot be an electric force even with a charge present. It is similar to a "if a tree falls in the woods" analogy. If there is a charge but no potential for it to present itself, there is still a charge "with nobody to hear it".

An old fashioned (non-flat screen!) television tube works by accelerating electrons (m = 9.11 *10^-31 kg, q = 1.6 * 10^-19 C) using an electric field and firing them toward a phosphorescent screen. They actually hit the screen moving at about one quarter of the speed of light! (The speed of light is 3 * 10^8 m/s). Calculate (using reasonable estimates for the input quantities) the electric field, assuming it provides a uniform acceleration over the entire distance.

Simple kinematics will solve the problem:

The **electric field E = electric force/electric charge**.

The **electric force = mass of electron * acceleration of electron**.

Assuming the electron was fired from rest, it means the initial velocity Vi= 0. Since it hits the screen at about 1/4 * 3*10^8m/s , it means the final velocity Vf=3/4*10^8m/s.

Assuming the electrons travelled a distance of about 5cm before hitting the phosphorescent screen, it means d= 0.05m.

Using Vf^2 =Vi^2 +2ad, **a =(3/4*10^8m/s-0)^2/(2*0.05m) = (9/16 *10^16)/0.1m/s^2 =9/16*10^17m/s^2**.

E=9.11*10^-31 kg * 9/16 *10^17 m/s2 /1.6 * 10^-19 C **which is approximately 250000N/C**

It’s interesting to calculate the time required first:

I estimate the "depth" (front to back) of an old TV to be about 1/3 m. With uniform acceleration, (and starting from a stationary position) the position of the electron in question can be described by x(t) = (a/2)t^2, and its velocity can be described with v(x) = a*t. Assuming the electron starts stationary, the average speed throughout its journey should be v_av = 0.25C(.5) = (1/8)C = (1/8)3*10^8 m/s. We'll estimate this to be about v_av = 3*10^7 m/s. Thus, the time that the journey takes (approximately):

delta t = (distance/v_av) = (.33 m)/(3*10^7 m/s) = .11 *10^-7 s = 10*-8 s

Now, we use this to find the acceleration of the atom. With constant acceleration:

a = (delta v)/(delta t) = (3*10^7 m/s)/(10^-8 s) = 3*10^15 m/s^2

Now, we use this to find the force on the electron using F = ma:

F = ma = (9.11*10^-31 kg)(3*10^15 m/s^2) = 30*10^-16 N = 3*10^-15 N

Finally we find the electric field using E = F/q:

E = F/q = (3*10^-15 N)/(1.6*10^-19 C) = 2*10^4 N/C

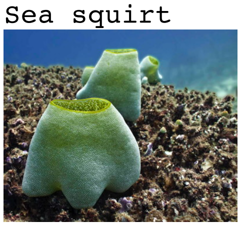
So the electric field E = 2*10^4 N/C pointing **in the direction of the screen**.

WARNING! Avoid reaching for Coulomb’s law as your first option!

The electric field is equal to Ke times the strength of the charge divided by the radius squared. This is equal to roughly Ke (9*10^9 kg*m^3/s^2*C) times Q(1.6*10-19^C) divided by the radius squared, which is roughly .5m for an old TV. Therefore, dividing Q by .25m gives us roughly 4*10^-18m/C times Ke gives us roughly 3.6*10-8m^2*kg/s^2 for the electric field.

The electric field lines from a lone charge looks most like a

Sea squirt



Sea urchin

Sea horse

Sea gull