Last week we discussed electric fields in empty space, now let's worry about electric potential. Can there be a non-zero electric potential at a position in in space where there is no electric charge? Can there be a charge at a position where the potential is zero? Discuss thoroughly, and construct an example if you think it's possible.

Value of potential is always relative to some reference point

Yes, there could be a non-zero electric potential at a position in space where there is no electric charge, because **this means the potential at this point is different than another point that has a defined potential of zero**. The potential can be defined as zero wherever is convenient, so the potential of any other point in space is defined relative to this reference point and the surrounding charge distribution. So **there can be a charge at a position where the potential is zero if we define the position to be zero at that point, the reference point.**

Using a standard reference point for zero potential, such a point still exists

No, the fact that the electric field is zero at a particular point, it does not necessarily mean that the electric potential is zero at that point. For instance **in the case of two identical charges, separated by some distance. At the midpoint between the charges, the electric field due to the charges is zero, but the electric potential due to the charges at that same point is non-zero**. The potential either has two positive effects, if the charges are positive, or two negative effects, if the charges are negative.

Good, specific examples

Yes, there can be a non-zero electrical charge at a position in space where there is no electrical potential. Using the example from the notes, **the electrical potential at the midpoint between the positive and negative particles will have a non-zero value, while the electrical charge will be zero**. Since the electrical potential is a scalar quantity and therefore the value is independent of direction. **Both the charges will have opposite signs but an equal magnitude. Since both these charges are of equal magnitude the electric potential will be zero**. However the electric field is a vector quantity and therefore relies on direction and magnitude. Since one charge is negative and one is positive, the electric field will be in the direction of the negative particle and nonzero.

There can also be a non-zero electrical potential at a position in space where there is no electric charge. **Using the same example, but with particles of the same sign, using the same logic as before, the charges will have an equal magnitude but the same sign**. Therefore a non-zero electrical potential. The electrical charge will rely on the same logic, but since the signs are the same, the electric field will be a zero value.

A television set accelerates electrons ($m = 9.11 * 10^{-31}$ kg, $q = -1.6 * 10^{-19}$ C) into a beam by sending them through an electric potential difference. They then excite the phosphor on your TV screen and show you strange pictures of strange people. Anyway, you know that the speed each electron has when it hits your screen is about one quarter of the speed of light, right? (The speed of light is $3 * 10^8$ m/s.) Find the potential difference through which they are accelerated. (Note to physics nerds: you don't need to worry about relativistic effects for this estimate.)

Reasonable assumption not knowing how a TV produces voltage

Assuming a tv has similar voltage to a light bulb, I would estimate a tv has a voltage of around 120 volts. Using the formula delta V = Vb - Va, this would give a potential difference of 120 volts through which the electrons are accelerated.

Do not reach for Coulomb's law as your primary equation of choice!!!!!

To find the voltage difference, you must find the electric potential at the front and back of the tube. Using the force required to accelerate the electrons calculated last time the charge of the screen can be calculated using **$F=k*q*q / r^2$.** .... The potential difference is just this divided by the charge of an electron since that is the charge being moved or 0.002407 J / $1.6*10^{-19}$C = **$1.504*10^{16}$ Volts**.

From my own experimentation with flyback transformers, **I know this voltage is many orders of magnitude too high. In reality the voltage difference is something like 100,000 volts max**.

Conservation of energy is your friend!

The potential energy lost by the particle accelerating from rest will be completely transferred to kinetic energy. Using:
Δ KE = Δ EPE.

Sine KE = 1/2 mv^2 and EPE = q (Δ V). Rearranging you get:

$\Delta V = mv^2/2q$.

$\Delta V = (9.11 * 10^{-31}) (\mathbf{3*10^8})^2/2(-1.6*10^{-19})$

units: kg * (m/s)^2/C = N * m/C = J/C   checks

$\Delta V = (9 * 10^{-31}) (9 * 10^{16})/(-3 * 10^{-19})$

$\Delta V = (9 * 9)/(-3) * (10 ^ {(-31+16)})/(10^{-19})$

$\Delta V = 27 * 10^4$

The potential difference through which they are accelerated is $27 * 10^4$ J/C

If you move in the direction of the electric field, the electric potential must

a. Increase
b. Decrease
c. Stay the same
d. depends on the sign of the charge being moved