The Radiation Mechanism

An intuitive understanding of the origins of radiation can be gained by associating radiation with the *acceleration of charge*. In fact, this notion can be mathematically proven from Maxwell's equations, but it is beyond the scope of what we wish to discuss here. Instead, if we accept that radiation is produced by the acceleration of charge, then consider the diagram shown in Figure 1.

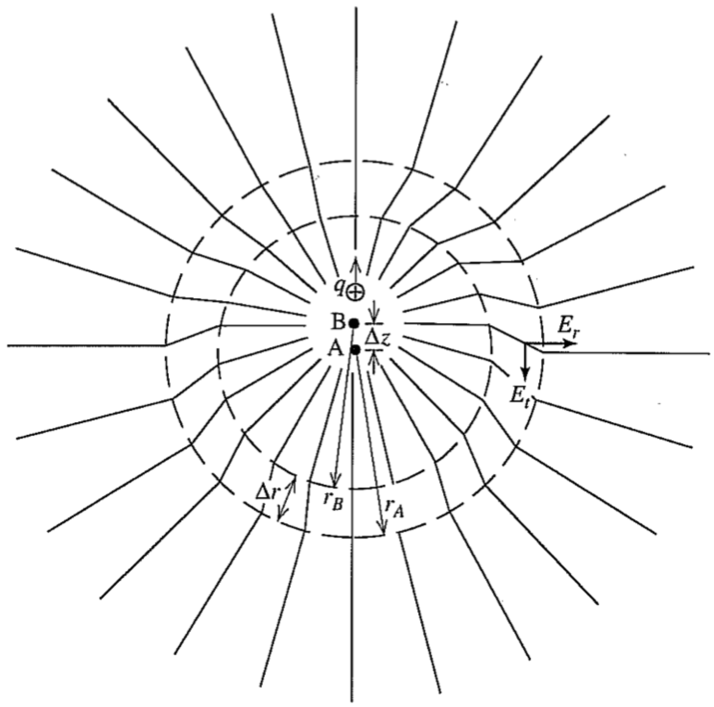

Figure 1: Accelerating charge

Consider a point charge q in a vacuum moving at a constant, non-relativistic velocity $v \ll c$ along the z-axis (vertical direction) for $t < 0$. At $t = 0$, the point reaches the point A shown in the diagram. We can sketch radial field lines diverging away from the point charge at A, which are shown in the lines outside the largest circle shown in the diagram.

At $t = 0$, the charge begins to accelerate until it reaches point B, at which point it resumes travelling at a constant (higher) velocity. The time interval between points A and B is denoted as Δt, and the distance travelled between those two points is Δz. The field lines produced by the point charge at B are sketched inside the innermost circle.

Since we associate charge acceleration with radiation, then if the two circle represent wavefronts then the difference in their radii must be

$$\Delta r = r_A - r_B = c\Delta t \tag{1}$$

since the propagation velocity of a wave in a vacuum is the speed of light c. Notice that the difference in radii is shown to be larger than Δz. This is consistent, since the speed of the charge was assumed to much smaller than the speed of light. In fact, the diagram has been purposefully exaggerated for clarity when in fact, $\Delta z \ll \Delta r$.

Electric field lines must be continuous. If we now join the field lines produced by the charges at the two points, we see that they are generally discontinous. *This discontinuous or disturbed field structure is radiation*. Interestingly, we see the field structure is not disturbed along the direction of the charge velocity. Conversely, normal to that direction, there seems to be the most radiation with the disturbed field having both a radial component E_r and a tranverse component E_t. We will see later in the course that the tranverse component persists far away from the antenna, and also that linear antennas (with charges confined to a line) do not radiate along their axes.

Hence, an antenna can be thought of any structure that facilitates the acceleration and deceleration of charge in a way that promotes radiation. Truncated wires are good examples of such structures because charges must decelerate to have zero velocity at the ends of the wire. We will explore a variety of antenna structures in this course.