Notes on Radiation

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Radiation from arbitrary source

Let's start with the retarted sources which give us the scalar and vector potentials

$$\mathbf{\Phi}(\mathbf{r},t) = \frac{1}{4\pi\epsilon_0}\int d^3r' \frac{\rho(\mathbf{r}, t - \frac{|\mathbf{r}-\mathbf{r}'|}{c})}{|\mathbf{r}-\mathbf{r}'|} \tag{1}$$

$$\mathbf{A}(\mathbf{r},t) = \frac{\mu_0}{4\pi}\int d^3r' \frac{\mathbf{J}(\mathbf{r}, t - \frac{|\mathbf{r}-\mathbf{r}'|}{c})}{|\mathbf{r}-\mathbf{r}'|}. \tag{2}$$

The first approximation for radiation is that the source is localized (also meaning that the radiation zone is far from the source $r \gg r'$. When calculating