

Problem Set 1

1 Adding waves

Suppose we have two 1D electromagnetic “plane” waves:

$$\begin{aligned}E_1(x) &= E_1 e^{i(k_1 x + \omega_1 t)} \\E_2(x) &= E_2 e^{i(k_2 x + \omega_2 t)}\end{aligned}$$

- 1.1 Suppose $E_1 = E_2$ and $k_1 = k_2$, but $\omega_1 \neq \omega_2$. Show that the energy density of these waves is, on average, the same if they are superimposed versus evaluated separately.
- 1.2 Show the same for plane waves travelling in opposite directions (i.e. $E_1 = E_2$, and $\omega_1 = \omega_2$, but $k_1 = -k_2$).

2 Order-of-magnitude electronic transitions

- 2.1 Provide an order-of-magnitude derivation estimating the energy required to ionize hydrogen, assuming a classical Bohr atom.
- 2.2 In what waveband would this transition emit/absorb a photon?

3 Cyclotron

Suppose you have a (non-relativistic) electron spinning circles in a magnetic field.

- 3.1 Show that the frequency of oscillation does not depend on the velocity of the electron.
- 3.2 In what waveband would an electron spiralling in the Earth’s magnetic field emit?

4 Fourier Transforms

For each of the Fourier transforms that AstroBaki says you should “just know”:

- 4.1 Numerically construct an example waveform and plot it (assume the x axis is time).
- 4.2 Plot the Fourier transform of that waveform with correct frequencies identified.
- 4.3 Identify the analytic function (with correct numerical coefficients) that corresponds to the input waveform and its Fourier transform.