Problem Set 1

1 Adding waves

Suppose we have two 1D electromagnetic "plane" waves:

$$E_1(x) = E_1 e^{ik_1 x + \omega_1 t} \quad (1)$$
$$E_2(x) = E_2 e^{ik_2 x + \omega_2 t} \quad (2)$$
$$(3)$$

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.**