PHY4311 ASSIGNMENT 2

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Problem 1. What is the coherence length for light with a bandwidth of 1MHz and 100THz?

1 MHz

The coherence time for this light is $\Delta\tau = 1/\Delta\nu = 1/10^6\text{Hz} = 1\mu\text{s}$. So the coherence length is

$$\Delta z = c\Delta\tau = 3 \times 10^8(10^{-6}) = 300\text{m}$$

100 THz

$$\Delta z = c\Delta\tau = \frac{c}{\Delta\nu} = \frac{3 \times 10^8}{10^{14}} = 3 \times 10^{-6}\text{m} = 3\mu\text{m}$$

Problem 2. Power per solid angle

a) Estimate the power per solid angle for a 100 Watt light bulb.

Let's assume that the electrical power gets converted to light power with 60% efficiency, so the light bulb radiates 60W of light. Imagine a unit sphere surrounding a lightbulb (so the lightbulb is inside the sphere). The light from the lightbulb goes out radially from the lightbulb and by the time it reaches the sphere the light covers an area equal to the surface area of the sphere, or $4\pi(1\text{m})^2 = 4\pi\ \text{m}^2$. So the power per unit area is $60W/4\pi\text{m}^2 = 4.77\text{W/m}^2$.

To get the power per unit solid angle, we multiply this by the square of the distance between the lightbulb and the surface of the sphere, which is 1 m. Our estimate for power per unit solid angle (radiant intensity) is then

$$I = \frac{60}{4\pi}(1)^2 = 4.77\frac{\text{W}}{\text{sr}}$$

b) Do the same for a 1mW laser.

Take a laser and put it inside a unit sphere like with the lightbulb. The laser is much sharper than a lightbulb and based on a laser pointer you might buy from a hardware store, the laser beam diverges to a width (diameter) of 0.5cm by the time it reaches the sphere. The beam covers a circular area of $A = \pi(0.25 \times 10^{-2})^2 = 1.96 \times 10^{-5}\text{m}^2$ on the sphere. We'll take the power emitted by the laser and divide it by the area the beam covers at the unit sphere and get

$$1 \times 10^{-3}/1.96 \times 10^{-5} = 51.02\frac{\text{W}}{\text{m}^2}$$

The radiant intensity is obtained by multiplying by 1m^2

$$I = 51.02\frac{\text{W}}{\text{sr}}$$

which is a lot higher than the lightbulb.