Thin Film Problem

- What is the reflectance of a glass (n=1.5) surface with a $MgFl_2$ coating (n=1.38) optimized for 550 nm light for
  1. 550 nm light
  2. 400 nm light

- Step 1: What is the thickness of the coating?

$$t_{dest} = \frac{1}{4}\frac{\lambda}{n_c} = \frac{1}{4}\frac{550}{1.38} = 99.64 \text{ nm}$$

- Step 2: What is the amplitude of reflectance at the surfaces?

$$r_1 = \frac{n_c - n_{air}}{n_c + n_{air}} = \frac{1.38-1}{1.38+1} = 0.16 \qquad r_2 = \frac{n_g - n_c}{n_g + n_c} = \frac{1.5-1.38}{1.5+1.38} = 0.0417$$

- Step 3: For 550 nm light….

$$I_{coherent} = \left(E_1 + E_2\right)^2 = A_1^{\;2} + A_2^{\;2} + 2\cdot A_1 A_2 \cos\left(p_1 - p_2\right)$$

$$p_1 - p_2 = 180 \text{ since they are out of phase}$$

$$I_{coherent} = A_1^{\;2} + A_2^{\;2} + 2\cdot A_1 A_2 \times(-1) = 0.159^2 + 0.0417^2 - 2\times 0.159\times 0.0417$$

$$= 0.0138 \equiv 1.38\%$$

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- Step 4: For 400 nm light, what is the phase difference?

$$\Delta waves = \frac{2 \times 99.64}{400/1.38} = 0.687 \text{ waves}$$

$$\Rightarrow \Delta phase = 0.687 \times 2 \times \pi = 4.32 \text{ radians}$$

- Step 5: For 400 nm light

$$I_{coherent} = \left(E_1 + E_2\right)^2 = A_1^{\,2} + A_2^{\,2} + 2 \cdot A_1 A_2 \cos\left(p_1 - p_2\right)$$

$$I_{coherent} = 0.159^2 + 0.0417^2 - 2 \times 0.159 \times 0.0417 \times \cos\left(4.32\right)$$
$$= 0.0219 \equiv 2.19\%$$

400 nm light is more reflective than 550 nm light, as expected. Reflectance was not zero for 550 nm light because the amplitude condition was not met.