PH 632

DAY 23

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Last time $\tilde{n}^2 = \frac{\epsilon}{\epsilon_0} + \frac{i\sigma}{\epsilon_0 \omega}$ when $\mu = \mu_0$

$$\tilde{n} = n + i\kappa$$

The real part of $\tilde{n}$ is called "refractive index"

The imaginary part of $\tilde{n}$ is called "extinction coefficient"

You can find n & κ for different materials tabulated on the internet

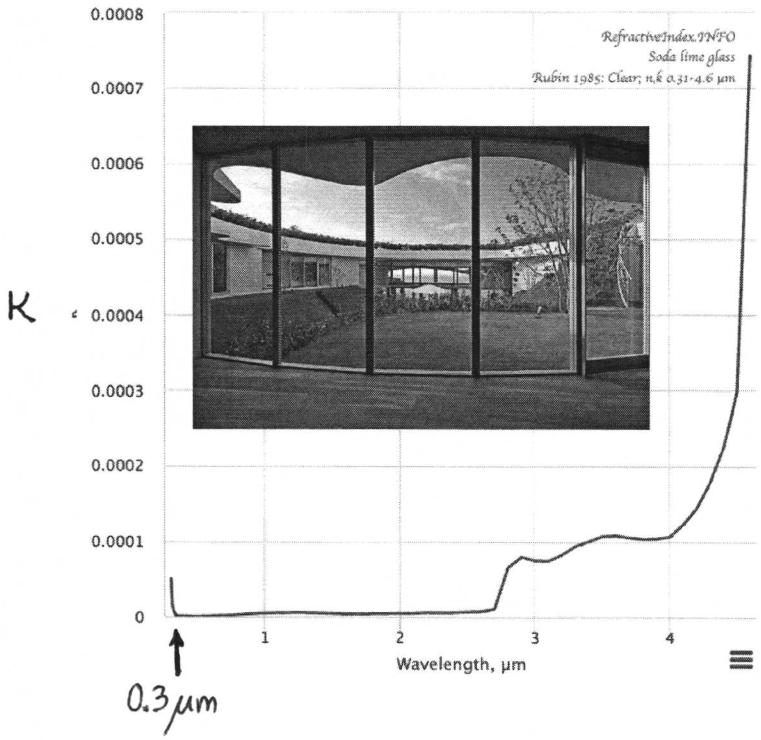
Example: Gold

λ_0	n_{Au}	κ_{Au}
300nm	1.73	1.87
400 nm	1.53	1.84
500 nm	0.86	1.85

Since $\tilde{k} = (n + i\kappa)k_0$ the exponential decay envelop is described by $e^{-\kappa k_0 x}$

and $\delta = \frac{1}{\kappa k_0} = \frac{1}{\kappa}\frac{\lambda_0}{2\pi}$

PH632 Pop Quiz, Day 23



Source: http://refractiveindex.info/

Windows are 5 mm thick and made out of soda lime glass: SiO_2 (72%) + Na_2O (14.2%) + CaO (10.0%) + MgO (2.5%) + Al_2O_3 (0.6%). The graph above shows the extinction coefficient, κ, (imaginary component of the refractive index) for soda lime glass. The extinction coefficient rises rapidly for $\lambda < 300$ nm.

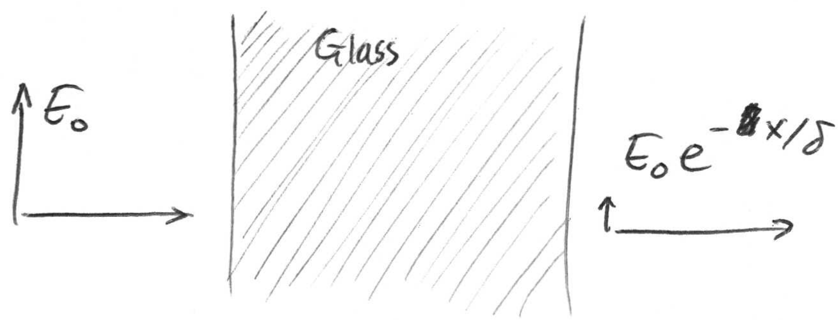
Consider UV light with wavelength 280 nm for which $\kappa \sim 10^{-4}$. How much of this UV light would pass through the window?

Answer to pop quiz:

If $k = 10^{-4}$ then $\delta = \dfrac{10^{4}\ 0.28 \times 10^{-6}}{2\pi}$

$$= \frac{28}{6}\ 10^{2}\ 10^{-6}$$

$$= 4.5 \times 10^{-4}\ \text{m}$$



, where $x = 5 \times 10^{-3}$ m

$I_I \propto E_0^2$ $\qquad$ $I_T \propto |E_0 e^{-x/\delta}|^2$

$$\frac{I_T}{I_I} = e^{-2x/\delta} = e^{-20}$$

The fraction of light transmitted.

Basically zero.

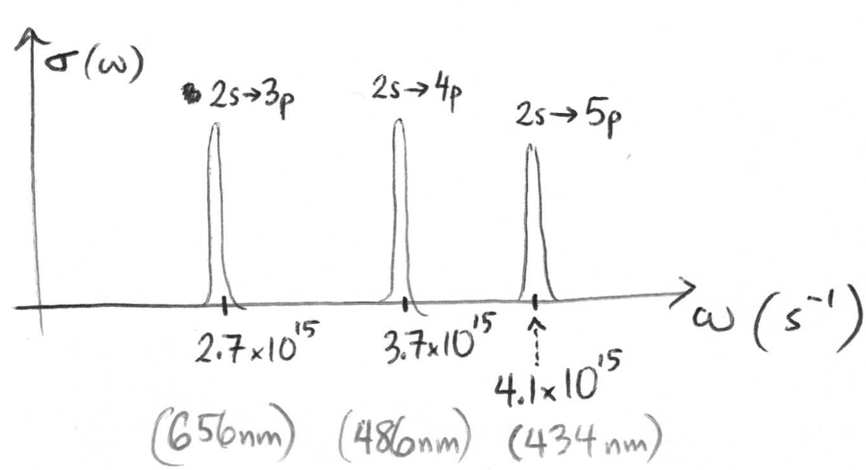
How can $\tilde{n}$ be complex in a material like glass which is "non-conducting"?

- We've shown that materials absorb EM radiation when the $\vec{E}$-field drives a current $\vec{J}_{free}$ that is in phase with $\vec{E}$ (work done on the charge equals force time distance).

- There is a second way for a material to absorb EM radiation. Electrons can be excited to higher energy quantum states.

Quantum transitions are conveniently described by the quantity $\sigma(\omega)$, "optical conductivity".

Example: Hydrogen Gas



Optical conductivity is high when the frequence is resonant with an energy level transition.