③ Interference between E/M Radiation of Different Wavelengths

We all know that light from a single coherent source can create interference patterns and such. What about arbitrary uncorrelated sources?

There will be interference but you won't see any visible patterns unless the two sources are phase locked to each-other since even the tiny differences in wavelength between supposedly identical lasers (HeNe, for example) translate into beat frequencies of MHz or GHz!

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The short answer is yes.

Let's just do the math. For a wave-number k (2pi over wavelength), ordinary interference from two point-like apertures goes like:

$$\begin{aligned} Psi &= (e^{(ik(L+a).)} + e^{(ik(L-a).)})/2 \\ &= e^{(ikL)} * \cos(ka) \end{aligned}$$

$$I = Psi^* \, Psi = \cos^2(ka)$$

(a is actually like $(x-d)^2/L$ where 2d is the slit separation, and x is the position along the screen; L is the distance from the center of the slits to our point on the screen).

Now for different wavenumbers:

$$Psi = (e^{(ik(L+a).)} + e^{(iK(L-a).)})/2$$

$$\begin{aligned} I = Psi^* \, Psi &= 1/2 \, [1 + \mathrm{Re}\{ e^{(i (k(L+a) - K(L-a)).)}\}] \\ &= 1/2 \, [1 + \cos(L(k-K) + a(k+K))] \\ &= \cos^2[1/2(L(k-K) + a(k+K))] \end{aligned}$$

This is almost a nice interference pattern as we vary 'a', but we've got some nasty L dependence, and in the regime L >> a where our approximations are valid, the L dependence will dominate the a dependence (unless (k-K) is very small; in particular, we'll get interference roughly when a(k+K) ~ 10 and L(k-K) ~ 1 , and L >> a , which implies |k-K| << |k+K| , nearly equal wavelengths.)

The L dependence is the usual phenomenon of "beats" which is also a type of interference, but not the nice "fringes" we get with equal wavelengths (the L dependence is like a Michelson-Morely experiment to compare wavelengths of light, by varying L (the distance between the screen and the sources) I can count the frequency of light and dark flashes to determine k-K.