

Re: how does light cause interference phenomena?

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Tom Roberts writes

>John Kennaugh wrote:

>> I am under the impression that very early radio transmitters, which
>>used sparks were in effect EM noise generators.

>

>Yes. As are modern radio transmitters, and electronic signal generators
>of all sort. What differs is the bandwidth of the output signal -- very
>early radio transmitters used a spark gap to generate a wideband noise
>signal, and this was filtered with one or more LC circuits to limit the
>bandwidth to a somewhat narrow region of the spectrum. A modern radio
>transmitter uses a high-gain amplifier in a feedback loop to generate a
>signal with an enormously-smaller bandwidth (and stability, etc.).

>

>

>> It was not until the thermionic valve oscillator was invented that
>>sinusoidal EM radio waves could be generated.

>

>Hmmm. Strictly speaking, of course, they are not perfect sinewaves, but
>have finite bandwidth. It's just that for most modern oscillators the
>output bandwidth is smaller than the resolution of common test
>equipment. Here "modern" merely means an oscillator based on a
>high-gain positive feedback loop, using vacuum tubes or transistors.

If you design an oscillator and you want to produce as pure a sinewave as possible you make the overall gain = 1. I don't know where you get this high gain stuff. By overall gain I mean the combined gain of the maintaining amplifier and the loss of the frequency determining circuit e.g. the crystal. Any more gain and the amplitude will continue to increase until the waveform distorts. If less than 1 it won't oscillate at all.

It is true to say that there is no such thing as a noise free sinewave because no one has invented a noiseless amplifier. However bandwidth is defined (for good mathematical reasons) as the difference between the frequencies of the upper and lower half power (-3dB points). If you have a good signal to noise ratio the actual bandwidth so defined is

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exceedingly narrow because any noise is well below the 3dB point and does not effect the bandwidth. I do not know if there is any theoretical limit to how good a sinewave can be produced, in engineering terms you put in as much development effort as necessary to get it as good as it needs to be. At the end of the day if you produced the purest sine wave of all time you would not have anything better to measure it with :o)

>> *My understanding is that something like a filament light bulb
>>generates light 'noise' and that it was not until the invention of
>>the laser that light joined radio in producing a pure waveform.*
>
>*The exact same remarks above apply -- the laser merely has a greatly
>reduced output bandwidth (and stability, etc.).*
>
>*Note that all common He-Ne lasers are multimode, and their output
>consists of several (typically 5-8) narrow peaks separated by typically
>1 part per million or so -- they are not at all a "pure waveform". This
>is for a common He-Ne laser, and semiconductor lasers are different
>(much wider output bandwidth with individual modes indistinguishable);
>ditto for Nd:YAG lasers. Laboratory He-Ne lasers can achieve singlemode
>output, but that takes refined technique and exquisite care in setting
>it up. A multimode laser typically has an output bandwidth of perhaps
>5-10 parts per million of its frequency (quite narrow by most
>standards); a singlemode laser can be a thousand times narrower than that.*
>
>
>*BTW the narrow bandwidth of a tube or transistor oscillator comes
>primarily from its high gain.*

How high is 1 :o)

> *The narrow bandwidth of a multimode laser comes from the sharpness of
>the atomic transition involved. The narrow bandwidth of a singlemode
>laser comes from the sharpness of the Fabry-Perot interferometer formed
>by its mirrors. This last is significantly narrower than the others.*
>
>
>> *If I have that right, and it seems logical that a filament should
>>produce light via a random process then it is the em equivalent of
>>band limited noise.*
>
>*Yes, a filament produces light via a random process: thermionic
>emission. But all sources of any type of signal are "band limited
>noise" -- the differences are in the bandwidth, not the principle.*

Here we must disagree. Noise is something produced by a random process. It has a wide bandwidth. If you halve the bandwidth you halve the power. If you keep halving the bandwidth you will get less and less power. Eventually you will get a pure sinewave of zero amplitude.

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The output of a crystal (or any) oscillator is not a random process any more than the movement of the balance wheel in a clock is random. If you did the same for the output of a crystal oscillator (kept halving the bandwidth) you would just get an even cleaner sinewave.

Interference requires a repeating pattern with time. You delay the pattern and add it back with itself you get a predictable result. That cannot happen with a truly random pattern. It does happen with thermally generated light therefore thermally generated light cannot be random and must have structure.

>
>
>> *Scott Murray suggested (from theory underlying the laser) that when a photon is randomly emitted it acts like a catalyst and stimulates the emission of a mass of other photons.*
>
>*This only happens if there is a "population inversion" present in an amplification material. And even then the gain is very low unless you arrange for multiple passes through the medium, as in a laser (typically the light bounces back-and-forth ~20-100 times in a well-built laser).*

You are confusing what I am saying. I shouldn't have mentioned lasers. I am talking about a filament. The excitation is thermal. Photons will be given off as a means of losing the thermal energy. All I am suggesting is that the timing is in naturally synchronised bursts.

Consider a bubble chamber. A super heated liquid is already at a temperature at which it could be a gas. It doesn't take much to initiate that process. We assume in fact that in triggering the formation of a bubble a particle doesn't lose energy in the process do we not? If the atoms in a filament are already in a state where they could give off a photon then it is not unreasonable to suggest that a photon, of the same energy passing by, could trigger the release which was going to happen anyway.

>> *This would suggest that light from a filament is not in fact random but in short bursts of coherent light with no fixed phase relationship between one burst and the next but a fixed relationship within the burst.*
>
>*That is indeed the case. But individual "bursts" are basically a single photon.*

I don't accept that because you can get at least 1000 rings in a Newton's ring experiment. Can a single photon extend its influence over 1000 wavelengths?

>*The coherence length of a common He-Ne laser is usually a few centimeters, which means you can construct a hologram over a volume of*

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*>about that size. A singlemode laser can have a coherence length of many
>meters. IIRC a lightbulb has a typical coherence length of a few
>microns -- long enough to generate Newton's rings in soap bubbles and
>oil films, but not any larger-scale interference phenomena.*

You seem rather confused. Newton's rings have nothing to do with soap bubbles or oil films. But I am interested in your term "coherence length" how is that measured? It seems to be tied in with what I am taking about.

--

John Kennaugh

to email convert the number from hex to decimal