A largely classical experiment demonstrating retroaction

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1. The experimental set-up

We consider an apparatus as sketched in Fig. 1, inspired by Ref. 1, Fig. 4.5.d) (see pp. 134-5), where an experiment is discussed of A. Gozzini. Viz. we derive from this a method of producing two coherent light beams of slightly different frequencies, that can be recombined.

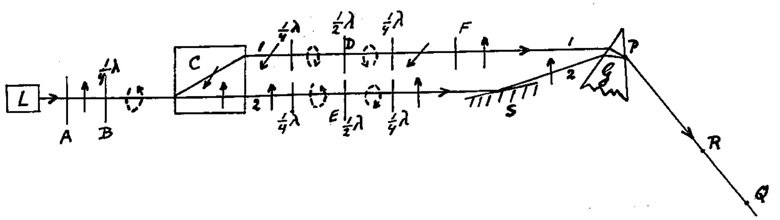

Figure 1. Fig. 1 Coherent beams 1 and 2 produce beats on PQ because of their slight wavelength difference.

L is a laser producing coherent light. Linear polarizer A and plate B produce right circularly polarized light from this. C is a calcite crystal splitting the beam into horizontally polarized component 1 and vertically polarized component 2. 1 and 2 are each conveyed through three plates as indicated, of which D and E both rotate at an angular velocity Ω in clockwise direction, seen from the left. As discussed in Ref. 1, D *diminishes* ray 1's frequency by Ω/π because D's and the incoming light's spin directions are anti-parallel, whereas ray 2's frequency ν is *increased* by the amount Ω/π in its passing E because the incoming 2 and E have parallel spin directions. So 1 and 2 now differ $2\Delta\nu = 2\Omega/\pi$ as to frequency. Device F rotates 1's polarization plane through $1/2\pi$ and mirror S reflects 2. Mirror S and prism G are set up so that the still coherent beams 1 and 2 both cover path PQ, where they interfere.

2. The production of beats on PQ implies retroaction

Precisely because rays 1 and 2 continue to be coherent in the sense that they remain capable of interference (recombination) after passing C and the $1/4\pi$ and $1/2\pi$ plates (see again Ref. 1), they will even continue to be so in together covering PQ. Because 1 and 2 have frequencies $\nu-\Delta\nu$ and $\nu+\Delta\nu$, respectively, their interference will produce beats with mutual distance d that can be found from formulas $d = (n+1)(\lambda-\Delta\lambda) = n(\lambda+\Delta\lambda)$ and $(\nu+\Omega/\pi)(\lambda-\Delta\lambda) = (\nu-\Omega/\pi)\times(\lambda+\Delta\lambda) = c$ if n is the number of waves between two successive beat maxima and $\Delta\lambda$ is the variation of λ going with a variation $\Delta\nu$ of the frequency. An elementary calculation shows that $d = \pi c/2\Omega$. Here we used $\Delta\nu = \Omega/\pi$ of Sect. 1.

Because 1 and 2, in interfering, continue to have velocities c, the above corresponds to beat maxima (and minima) passing an arbitrary point R on PQ at time intervals $\Delta t = d/c = \pi/2\Omega$. We can shorten d and Δt by inserting more than one rotating $1/2\lambda$ plates on 1 and 2's paths, which effects an increase of the difference $2\Delta\nu$ between the frequencies of both rays if we can no longer attain this by increasing Ω because of technical limits.

The implication of retroactivity by our experiment is that, since the beats correspond to variations of the stream of energy, or of photons, passing, say, R, *corresponding intensity variations have already to appear as to the energy or photon flux passing polarizer A, because such energy (photons) has a definite velocity c.* That is, already *before* the light's frequency is changed by the rotating $1/2\lambda$ plates, repercussions of such change appeared at A, or even in L. By varying Ω, we can therefore *retroactively manipulate* the energy flux passing A, that will show an intensity variation with period $\pi/2\Omega$. This will have its origin in either a retroactively effected modulation of L's emission activity or such modulation of A's transmission coefficient, which will be $1/2$ on an average.

3. Some additional remarks

(a) We cannot escape from the above inference of retroactivity, and of a "clustering" of the transmission of energy through A, by assuming some compensating absorption of photons by the apparatus : only a small fraction of the energy passing A gets lost.

(b) In order to produce long wave trains we need coherent laser light. This makes it also clear that we cannot produce a paradox (at least, conceptionally, not in practice) by first measuring variations of L's emission rate (e.g., by weighing it) and subsequently making the plates D and E rotate at angular velocities that do not correspond to the beat frequency indicated by the L measurement result. For, by our time measurements as to the energy flux, we perturb the energy E according to $\Delta E \Delta t \geq h$, which detracts from the light's coherence that is essential for our experiment, that thus becomes impossible. More precisely : we have to measure Δt to a precision $1/2\pi/2\Omega$; so ΔE satisfies $\Delta E \geq 4h\Omega/\pi$. That is, we perturb ν by $\Delta_1\nu = \Delta E/h \geq 4\Omega/\pi$, which is twice the original effect $2\Delta\nu = 2\Omega/\pi$ causing the beats. (We can argue similarly for measurements of A's transmission rate.)

(c) It has to be emphasized that our proposed experiment does not depend on parts of quantum mechanics that are deemed controversial by some, and that it can actually be performed.

(d) We do not only see "retroaction", in our experiment, via trajectories characterized by $s = \sqrt{c^2t^2 - x^2} = 0$ on the negative light cone half (that are normally covered by light in the positive direction), but we can produce it *within* the negative half of the light cone, too, by extra retarding beams 1 and 2 in the apparatus, so that their net velocity is definitely smaller than c.

(e) Of course, the energy-localizing or photon-clustering effect of the interference of monochromatic beams 1 and 2 is in principle comparable to the formation of (rather) localized wave packets by monochromatic Fourier components of slightly different wavelengths.

(f) Note that we cannot escape from the above conclusion of the existence of a retroactively induced modulation of the energy flux carried by the beam transmitted by A by invoking some uncertainty as to the length a of the optical path from A to, say, our test point R. For the variation of or uncertainty as to a effected by the beam's splitting and by differentiations of the light's velocity as regards separated components in the plates and other parts of the instrument is many orders of magnitude smaller than corresponds to the beat period $\pi/2\Omega$ which, moreover, can be varied. So one cannot argue that no special definite moment of transmission by A corresponds to, say, a beat minimum –that is, a minimum flux of energy– at test point R at a moment a/c seconds later.

(g) Note that the proposed experiment can in principle also be performed if we use coherent wave trains whose small frequency difference has been effected otherwise than in the way discussed above.

4. Even "ordinary" standing waves can demonstrate that retroaction appears in Nature

Consider a source M emitting an intense monochromatic stream of low-energy photons, say, corresponding to a wavelength $\lambda = 100km$. (See Fig. 2.) S is a mirror, so that standing waves are generated in region W. (We sketched the situation at a moment at which the returning beam did not yet reach M.) It is clear that nodes such as N and loops like L have mutual distances of $25km$ now. It is also clear that in principle we can make the waves even longer, and can also use slowly moving particles instead of photons, these again corresponding to large distances between nodes and loops.

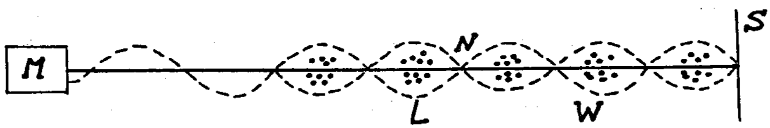

Figure 2. Fig. 2 Photon or particle standing waves demonstrating retroaction.

It is evident from a similar argument as that of Sect. 2 that M's energy and momentum (carrier) emission has to correspond to the clustering implied by the standing waves. Though the beats of our first experiment can more easily be made to have large mutual distances than the nodes and loops of the one of Fig. 2 and, therefore, illustrate the retroactive effect even more spectacularly, the latter appears in our present experiment, too. This is the more "outspokenly" so according as we use (possibly large numbers of) slowlier moving particles, e.g., needing an hour to cover one wavelength : their source, then, clearly emits energy in "clusters" separated by time periods of half an hour.

Note that orthodox quantum theorists may in the first instance try to escape the conclusion that retroaction appears from the above experiments by invoking "uncertainty" as to the moments of emission of relevant momentum carriers, but that realists who assume realistic photons or particles to travel from M and manifest themselves in the domain W find such way of escape blocked from the start. However, even Copenhagenists cannot really use it, either. For

a) Though the moment of emission of momentum carriers, according to their theory, is uncertain within a margin covering the whole emission period of the monochromatic waves, it gets definite and known at the *impact* measurements that we can perform in the loop regions ;

b) Because the *momentum* of the relevant particles is uncertain to a measure corresponding to a fraction of one wave out of the total number of waves n of the wave train $-\Delta p_x/p_x = 1/n-$, this uncertainty is far too small to make the particles' impact locations form clusters as discussed *without the emission times roughly doing so correspondingly.* For, e.g., we can consider a wave train of 1,000 waves (so that $\Delta p_x/p_x = 1/1000$) while actually using only a few waves as in Fig. 2. Then the distances ML and MN, or MSL and MSN, differ far more than corresponds to the fraction of 1/1000 that is actually available for allowing the particles (or the energy) to start "non-clusteredly" from M and, because of their different velocities, still to arrive at the region W according to the relevant clustered distribution ; note that, e.g., $LN/MSL \approx 1/20 \gg 1/1000$;

c) Also the borrow-from-God hypothesis, as to the clustered energy that has to be emitted from M and that corresponds to the loops and nodes distribution, can only be maintained if we admit that God has to be *retroactively* influenced so as to systematically and orderly produce periodic energy pulses –that is, lend energy– of far greater intensities than correspond to any known separate micro mass.

Mind in the above connection that we indeed can always decide "at the last moment" whether or not to make the reflection on S (the production of standing waves) happen. That is, we can decide so long after the relevant emissions at M whether the clustering in domain W will appear or not that retroaction is inevitable. (For the experiment of Fig. 2 compare also Ref. 2, pp. 67-69.)

Finally note that if the future can retroactively influence the present, as we saw above, such future has to actually exist and, therefore, has to be definite, "established", too. This means that our (thought) experiments imply that the Copenhagen and other fundamentally indeterministic ways of thinking no longer have a scientific basis and are untenable.

References

[1] F. Selleri, *Quantum Paradoxes and Physical Reality* (Kluwer Academic Publishers, Dordrecht/Boston/London, 1990).

[2] C.W. Rietdijk, *On the Explanation of Matter Wave Interference* (Van Gorcum & Comp., Assen, 1973), pp. 67-69.

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