The hidden arrow of electromagnetic radiation: unmasking advanced waves

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Advanced potentials are generally discarded on causal or statistical grounds, as a consequence of misinterpreting advanced waves as incoming waves. Perceiving advanced waves as incoming waves is an illusion created by an anthropocentric view of time. Seen from 'nowhen', outside a block of space-time, advanced waves are also outgoing waves, the cause and source of which is a transmitting antenna just as is the case for retarded waves. The transmitting antenna radiates advanced electromagnetic waves into free space, in line with Hoghart's calculations in the Wheeler-Feynman absorber theory for an open, ever-expanding universe. The reason advanced radiation is not observed is due to the act of the observation itself, in which lies a hidden mechanism that masks advanced waves. By introducing a receiving antenna, we introduce an absorber where its advanced waves cancel out the advanced waves of the transmitting antenna. However, advanced radiation may still be detectable if the impact of the measuring instrument on the phenomenon being measured is minimized, as recent experiments with radio waves have indicated.

That is precisely what common sense is for, to be jarred into uncommon sense. One of the chief services which mathematics has rendered the human race in the past century is to put 'common sense' where it belongs, on the topmost shelf next to the dusty canister labeled 'discarded nonsense.'

E.T.Bell

Unfortunately, Bell was wrong. Perhaps one of the most important decisions with far-reaching consequences for modern physics was made on the basis of common sense rather than relying on mathematics. Textbooks covering classical electrodynamics state that the advanced potentials are an equally valid solution to Maxwell's equations as well as for the retarded potentials. However, the advanced potentials are discarded as unphysical on causal grounds [1,2]. When mathematics contradicted his expectations of how nature should behave, Griffiths chose to believe in common sense and reject valid solutions from fundamental equations of physics as unphysical:

> Incidentally, this proof applies equally well to the **advanced potentials,**
>
> in which the charge and the current densities are evaluated at the **advanced time.**

A few signs are changed, but the final result is unaffected. Although the advanced potentials are entirely consistent with Maxwell's equations, they violate the most sacred tenet in all of physics: the principle of **causality.** They suggest that the potentials *now* depend on what the charge and the current distribution *will* be at some time in the future - the effect; in other words, precedes the cause. Although the advanced potentials are of some theoretical interest, they have no direct physical significance.

Time asymmetry is introduced when we select the retarded potentials in preference to the advanced ones, reflecting the (not unreasonable!) belief that electromagnetic influences propagate forward, not backward, in time [2].

The common sense belief that electromagnetic influences propagate forward, not backward, in time comes from experience gained by living in the macroscopic world of a large number of particles interacting in which all the processes that humans can perceive take place in the direction in which entropy increases. However, this does not mean that fundamental processes in nature must take place in the same way. If we trust mathematics rather than common sense, and accept that electromagnetic influences can propagate backward in time, then advanced waves are not source-less and non-causal. From the human perspective, the cause of advanced waves lies in the future – the effect precedes the cause, but that is just a matter of perspective. Humans are creatures that move along the time dimension in one direction, so the view of the time-symmetrical process is necessarily distorted when viewed from the human perspective. The only way to avoid such distortions is, as Price suggested [3], to move away and see things from a non-anthropocentric perspective, from 'nowhen' outside the block of space-time, in which all dimensions and directions are equal (Fig. 1).

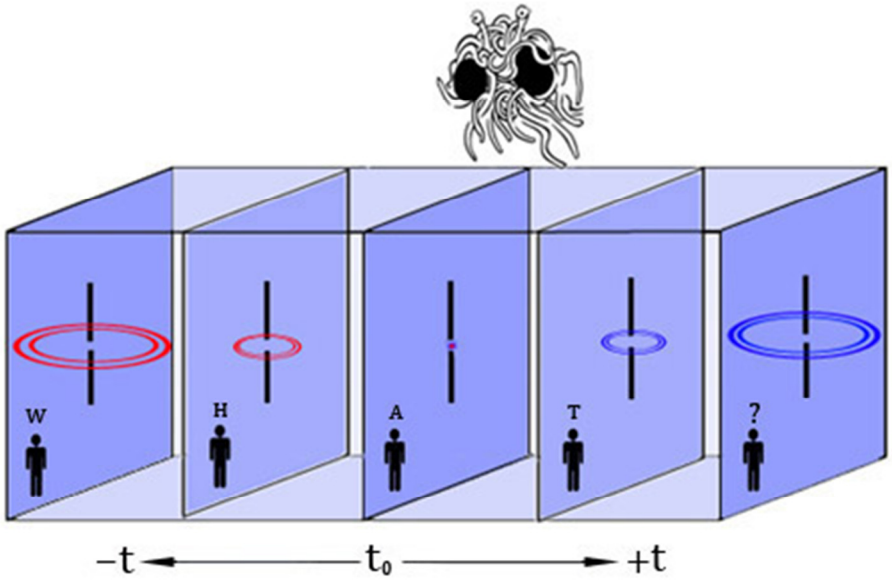

Fig. 1: The 'view from nowhen' of the process of emission of electromagnetic waves in free space. Advanced waves that spread from the antenna toward the past are shown in red. Retarded waves that spread toward the future are shown in blue. Both waves originate from the antenna at the moment of emission t_o. Both waves are outgoing. A confused human being, whose psychological experience of time has a preferred direction, misinterprets the advanced waves as incoming waves that emerge from infinity without causation and converge to the point at the location of the antenna, exactly at the moment of emission.

Seen from this perspective, a disturbance that originates at the antenna at a time t_o spreads symmetrically in both time directions. Both waves are outgoing. The transmitting antenna is the source of advanced waves as well as retarded ones. The misinterpretation of advanced waves as incoming waves has led many physicists and philosophers to the wrong conclusion, that the reason they do not appear in nature has a statistical origin – converging waves are possible but extremely unlikely because, in order to occur, they require the cooperation of a large number of distant sources in in the remote past to produce a precisely timed incoming wave of appropriate amplitude to converge into a point exactly at the moment of emission. Some examples are:

Einstein:

> According to our prevailing theory, an oscillating ion generates a spherical wave that propagates outwards. The inverse process does not exist as an elementary process. A converging spherical wave is mathematically possible, to be sure; but to approach its realization requires a vast number of emitting entities [4].

Popper:

> Suppose a film is taken of a large surface of water initially at rest into which a stone is dropped. The reversed film will show contracting circular waves of increasing amplitude. Moreover, immediately behind the highest wave crest, a circular region of undisturbed water will close in towards the centre. This cannot be regarded as a possible classical process. (It would demand a vast number of distant coherent generators of waves …) [5].

Davies:

> ... the reason we do not observe advanced electromagnetic radiation is precisely because such radiation would require strong correlations in the remote past between photons emerging from quite different directions. The probability of a random initial state of the electromagnetic field happening to give rise to coherent converging wave fronts of radiation is obviously staggeringly small [6].

If this interpretation of advanced waves is an illusion created by human experience of time, but in reality, they come from the same source as the retarded waves, and a radio transmitter emits equally advanced and retarded electromagnetic waves, why do we observe only retarded radio waves?

Fig. 1 shows the process of radiation in the absence of an absorber in both time directions, in other words, in the universe that is transparent to electromagnetic radiation in the direction of the past and in the direction of the future, which our universe is not. According to Davies [7], the open, ever-expanding universe, which is probably the universe we live in, is transparent to electromagnetic radiation in the direction of the future, and opaque in the direction of the past. In that case, according to Hoghart's [8] calculations, the Wheler-Feynman absorber theory [9,10] predicts that a radio antenna should emit advanced electromagnetic radiation into free space, as shown in Fig. 2. This is in direct contradiction with observation, so something is wrong with this picture, or is it not? To overcome this problem, various authors have offered different solutions. Hawking [11] concluded that because our universe is a big bang universe, the basic premise of Hoghart's paper must be wrong. Hoyle and Narlikar [12] have taken the prediction of retarded radiation for the steady-state universe as evidence that this is the kind of universe we live in. To save the Wheeler-Feynman absorber theory, Cramer [13] introduced a 'mirror' at the big bang, from which the reflected wave cancels the advanced wave up to the emission event, and at times after emission it reinforces the retarded wave from the emitter.

But what if Hogarth was right and something is wrong with our observation of electromagnetic radiation? What has been overlooked is that, when we introduce an instrument of observation to measure the radiation that a transmitting antenna emits into free space, we introduce a change in the situation shown in Fig. 2. By introducing a receiving antenna of the appropriate size, connected to a corresponding load, we introduce an absorber in the direction of radiation in which there was no absorber when no observation is made. By the act of measurement, we changed the situation shown in Fig. 2 to the situation shown in Fig. 3. In the act of observation lies a mechanism that masks advanced electromagnetic waves. The advanced waves of the receiving antenna cancel out the advanced waves of the transmitting antenna in the direction of the receiving antenna. In other directions in which there are no absorbers, the transmitting antenna radiates advanced electromagnetic waves into free space. The act of observation itself creates an illusion that the electromagnetic arrow points only in the direction of the future.

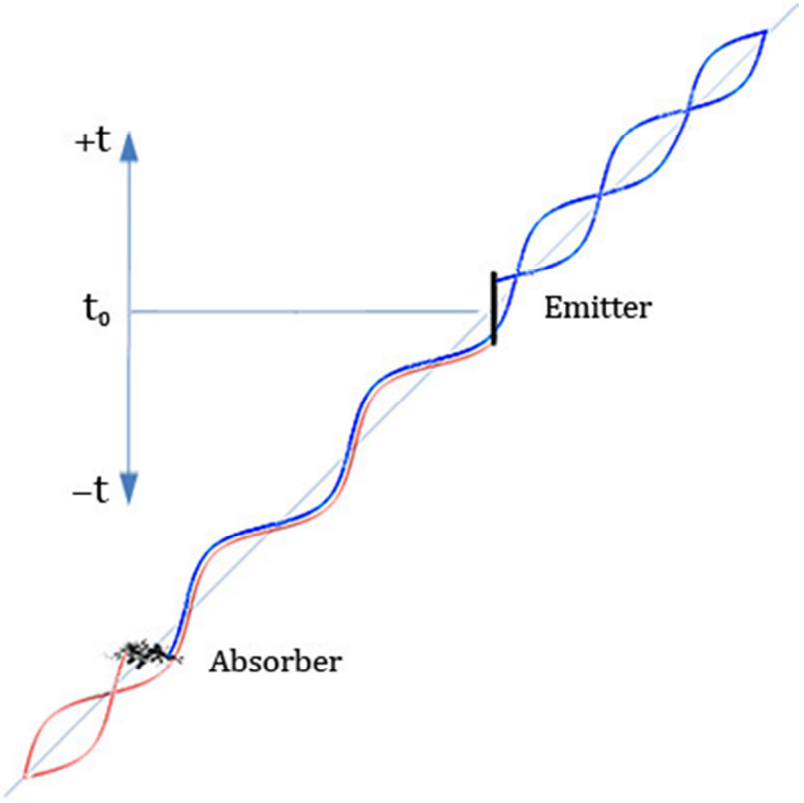

Fig. 2: The situation in the big bang universe that is transparent in the direction of the future, and opaque in the direction of the past. The emitter – the transmitting antenna, emits retarded waves (blue) in the positive time direction and advanced waves (red) in the negative time direction, toward the past absorber. The absorber in turn also produces advanced and retarded waves. The advanced waves are out of phase before the absorption event. The retarded waves of the absorber are in phase with the advanced waves of the emitter up to the moment of emission where they reinforce each other. Retarded waves are out of phase after the emission event. The electromagnetic arrow of time points in the direction of the past.

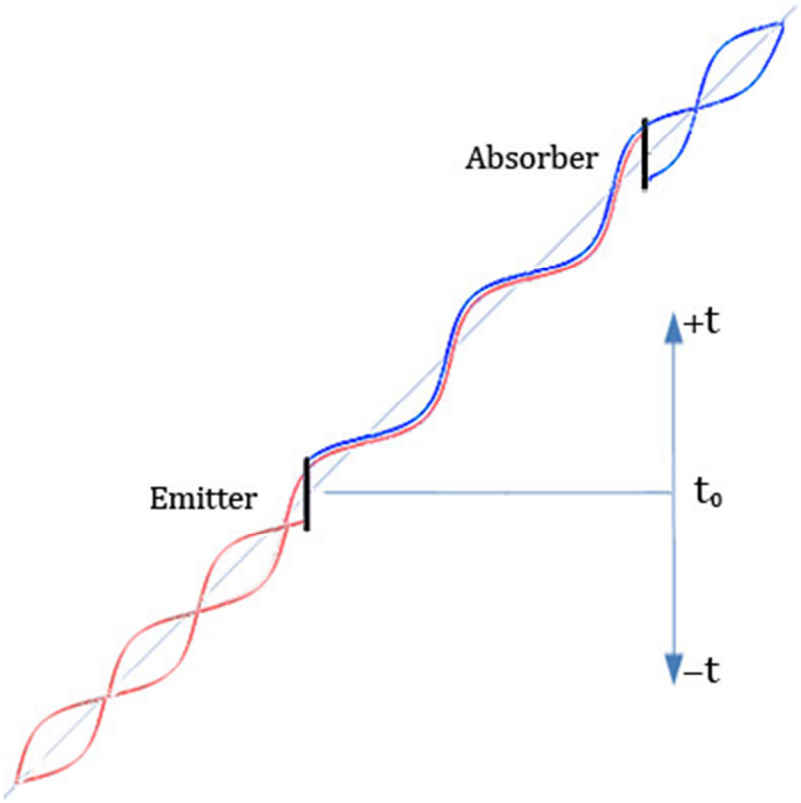

Fig. 3: By introducing the receiving antenna, the absorber is introduced in the direction where there is no absorber when no observation is made. The emitter emits retarded and advanced waves. The absorber – the receiving antenna, in turn also produces advanced and retarded waves. The advanced and retarded waves are in phase in the interval between the emission and absorption events. Advanced waves of the absorber are out of phase with the advanced waves of the emitter before the emission event where they cancel each other out.
The electromagnetic arrow of time points in the direction of the future when there is interaction with the instrument of observation or some other absorber in the environment.[1]

Is there any way to detect advanced electromagnetic waves that the transmitting antenna radiates into free space?
The solution to this measurement problem is to minimize the influence of the measuring instrument on the phenomenon being measured. This can be easily achieved with the meter and decimeter radio waves by using a small enough receiving antenna for detection, where its advanced waves cannot completely cancel advanced waves from the transmitting antenna. If the results of the recent experiments represent the real signal and not some systematic error, then the advanced radiation can actually be detected with a receiving antenna twenty times smaller than the wavelength of emitted electromagnetic pulses [14].

[1] Measurements of advanced radiation during the year indicate that the amount of water vapor in the troposphere has a significant influence on the advanced signal measured at low elevation angles. In the summer, when the amount of water in the troposphere is much higher than in the winter, the advanced signal can only be detected at high elevation angles closer to the zenith, in directions in which there is not enough water molecules to completely cancel out the transmitting antenna's advanced waves.

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