Comment on "Observation of image pair creation and annihilation from superluminal scattering sources" [1]

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In a recent paper [1] in this journal, the authors demonstrate the capabilities of their high-speed optical imaging equipment by observing the spatial and temporal behavior of a short light pulse, interacting with a scattering screen. However, they make the revolutionary claim that their measurement results can be interpreted as the effects of a superluminal light source, i.e. a source moving at a velocity larger than the vacuum speed of light *c*. Their "superluminal light source" cannot be considered as a radiating source traveling at a speed larger than *c*, but rather as a sequence of stationary sources which are successively excited by the pulse as its wavefront sweeps across the screen, leading to an apparent velocity larger than *c*, which is equal to the phase velocity of the pulse, measured in a direction parallel to the scattering screen. A phase velocity larger than *c* is nothing new. By invoking the questionable concepts of a "superluminal source of light", and "image pair annihilation" they sketch an unnecessarily complicated picture of the experiment. Moreover, their experimental results are easily explained by considering classical geometrical optics, as shown below.

In a first experiment a sub-ps light pulse in a collimated beam propagating in the x-direction of a Cartesian coordinate system impinges on a large scattering screen at an angle of incidence θ. The light beam is sufficiently wide to illuminate the full width of the screen. A high-speed camera with its optical axis oriented parallel to the y-direction images the screen, as schematically shown in Fig. 1.

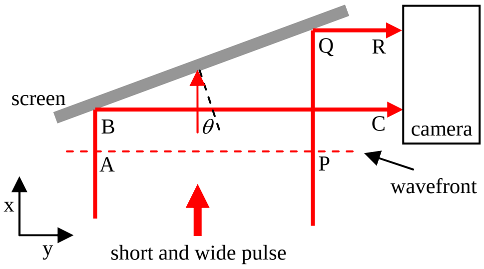

Fig. 1. Schematic view of the experimental set-up used in [1].

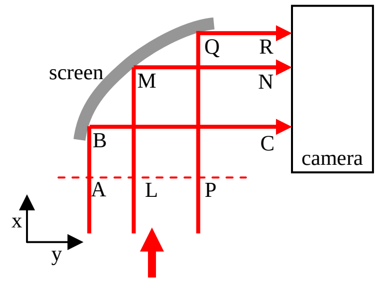

Fig. 2. Set-up with curved screen, used in [1]

A crucial point in all experiments is that the pulse duration τ is so small that the spatial length of the pulse is small compared to the screen dimensions. As a consequence an illuminated zone sweeps across the screen from point B to point Q. In the special case of $\theta = \pi/4$, all path lengths, such as ABC and PQR, from an incident wavefront AP to the camera plane are equal, so the light from all points on the screen will reach the camera simultaneously, homogeneously illuminating the camera for a duration τ. For other values of θ a spot moving in the positive ($\theta > \pi/4$) or negative ($\theta < \pi/4$) x-direction is observed on the camera. Geometrical optics provides a simple explanation: the length of different optical paths from an incident wavefront to the camera depends on θ. For example, if $\theta < \pi/4$ the distance PQR is shorter than ABC so obviously the light from the pulse will reach point R before it reaches point C, and the camera will record a spot traveling from R to C. Calculating the apparent velocity v_x of the pulse image by dividing the distance CR by the time difference $\Delta t = t_{ABC} - t_{PQR}$ between the arrival times at the camera for light of the pulse traveling along paths ABC and PQR, respectively, the same relation is found as was given by Eq. (2) in [1], corresponding to the measured velocity within experimental error as shown in Fig. 2D in [1].

In a second experiment the plane screen is replaced by a curved one. For a screen with a concave curvature, as shown in Fig. 2, two light spots are observed, originating at opposite edges of the screen, moving towards the center where they disappear, simply because the pulse has passed.

The term 'image pair annihilation' that is used by the authors seems to be inappropriate, since annihilation suggests a physical interaction between the images, comparable to what happens when an electron and a positron collide. The term might be applied to destructive interference, but even that is not the case in this experiment.

Again a simple geometrical interpretation can be given. For the orientation of the screen as implied in [1] where points B and Q in Fig. 2 are on a straight line, oriented at an angle $\pi/4$ with respect to the y-axis, the distances ABC and PQR are equal. Light following those paths will arrive simultaneously at the camera, producing two image spots at C and R. Other light routes will be progressively longer as the intersection of the pulse wavefront with the screen approaches the center. Let LMN be the longest path. Then the two spots will be observed to both move towards N, where they will disappear, not because they would 'annihilate', but just because the pulse has passed.

In conclusion, the paper needlessly introduces questionable physical concepts in order to explain measured phenomena that have a trivial explanation.

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[1] M. Clerici et al., "Observation of image pair creation and annihilation from superluminal scattering sources", Sci. Adv. 2016;2:e1501691 (15/04/2016).

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