Vacuum Laser Acceleration is an Example of a Classical Electromagnetic "Memory" Effect

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A recent paper [1] discussed a "memory" effect in classical electrodynamics. The Abstract stated that the "memory" effect is "... a prediction that an electromagnetic wave can leave a lasting influence long after it has passed. This influence is manifested in a velocity effect on a test charge." Classical manifestations of the "memory" effect include Rutherford scattering of two charged particles and so-called vacuum acceleration of charged particles by a laser pulse (first reported (1997) in Ref. [2]; two more recent discussions of vacuum laser acceleration are in Refs. [3, 4]).

In the quantum realm the photoelectric effect and Compton scattering are examples of an electromagnetic "memory" effect.[1]

References

[1] N. de Aguiar Alves and B.A. Costa, *Liénard-Wiechert potentials and the electromagnetic memory effect* (Sept. 15, 2026). To appear in the Am. J. Phys.
https://arxiv.org/abs/2609.20872

[2] G. Malka, E. Lefebvre and J.L. Miquel, *Experimental Observation of Electrons Accelerated in Vacuum to Relativistic Energies by a High-Intensity Laser*, Phys. Rev, Lett. **33**, 3314-3317 (1997). https://doi.org/10.1103/PhysRevLett.78.3314
https://kirkmcd.princeton.edu/examples/accel/malka_prl_78_3314_97.pdf

[3] P.K. Singh *et al.*, *Vacuum laser acceleration of super-ponderomotive electrons using relativistic transparency injection*, Nature Comm. **13**, 54 (2022).
https://doi.org/10.1038/s41467-021-27691-w
https://kirkmcd.princeton.edu/examples/accel/singh_nature_nc_13_54_22.pdf

[4] A. De Andres *et al.*, *Unforeseen advantage of looser focusing in vacuum laser acceleration*, Comm. Phys. **7**, 293 (2024). https://doi.org/10.1038/s42005-024-01781-9
https://kirkmcd.princeton.edu/examples/accel/deandres_cp_7_293_24.pdf

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[1] In private communications, the authors stated that their "memory" effect is not what is implied in their Abstract but something else not related to the examples I cite. One author agreed that Compton/Rutherford scattering is a "memory" effect, while the other did not.

The authors implied that their "memory" effect corresponds to a nonzero value of their eq. (45), in which $\mathbf{r}$ is a fixed observation point and the symbol T means the "in" values are for time $t_j = -\,\mathrm{T}$ and the "out" values are for $t_i = \mathrm{T}$, for some finite time T. [Note the confusion of the use of subscript i for the "out" charges rather than the "in" ones.] For vacuum laser acceleration of a single "test" charge, all "in" velocities $\mathbf{v}_j$ are zero at $t_j = -\,\mathrm{T}$, while all "out" velocities $\mathbf{v}_i$ associated with the laser are again zero at $t_i = \mathrm{T}$, but the velocity of the accelerated "test" charge is nonzero (at $t_i = \mathrm{T}$). Thus, it seems to me that vacuum laser acceleration is indeed an example of their "memory" effect, unless the authors now wish to disavow their eq. (45).