Kaplan and Shkolnikov Reply: Stupakov and Zolotorev (SZ) [1] suggest that our results [2] on the lasetron pulse coherency and duration are incorrect; they also cast doubts on the validity of our prediction of an ultrastrong magnetic field generated by the device. We show that these conclusions originate largely from the incorrect assumption in [1] about the nature of the motion of electrons in the lasetron and their radiation, as expressed in [1]: "The physics of [lasetron] radiation is the same as for an electron bunch in a synchrotron, the only difference being a minuscule scale of the orbit." This premise neglects fundamental differences between the electron motion in the synchrotron and the lasetron. In a synchrotron, electrons move in a large orbit, at only a tiny part of which they are accelerated by a driver, so that their phases are substantially random, whereas in a lasetron, the electrons are completely immersed in the driving laser field, so that each electron at each point of space and time is moved by the driver alone, with its rotational frequency and phase exactly equal to those of the laser field. This "master-slave" or "orbital-sander" motion is fundamentally different from the quasiresonant excitation by a synchrotron; by no means is the lasetron a "minuscule synchrotron."

SZ state "The authors claim that the duration of the pulse of the radiation will be given by their Eq. (1), $\tau_{pl} \sim 1/(2\omega_L \gamma^3)$... This, however, is true only for the radiation of a single electron; for an electron cloud of size $\sigma > \lambda\!\!\!^{-}$, the superposition of radiated pulses from different electrons would result in... $\tau_{pl} \sim \sigma/c$. For σ not much smaller than r this is about 5 orders of magnitude larger than given by Eq. (1)." This conclusion is incorrect even if the limit $\tau_{pl} \sim \sigma/c$ were absolute. Indeed, for $\gamma = 60$ and a quite feasible $\sigma \sim \lambda\!\!\!^{-}/100$, Eq. (2) for τ_{pl} in [1] yields pulses of only 3, not 5, orders of magnitude longer than those due to Eq. (1) in our work [2]; e.g., for $\lambda_L = 1\ \mu\mathrm{m}$, pulses of $\sim$2 attosecond duration would be generated, which are 2 orders of magnitude shorter than those achieved just a few months ago—not a small feat by any standards. Moreover, Eq. (2) in [1] implies that a system cannot radiate pulses shorter than the time it takes for the light to traverse the system. A femtosecond laser is an obvious example to the contrary. If the radiation is a collective process—as is the case with the lasetron—the length of the radiated pulse is closely related to its coherency. This problem was addressed by us in [2], albeit briefly. Our calculations, to be published, do show that the specific nature of the "sander motion" of electrons in the lasetron allows for coherent radiation by a cloud of much larger dimensions than those considered too big in [1], especially for a wire target; consequently, pulses of zeptosecond duration are possible for multielectron radiators.

After stating that an electron bunch will radiate coherently only if its volume is smaller than $V_{\mathrm{coh}} \sim \lambda\!\!\!^{-3} \gamma^2$, SZ conclude "that a microbunch... will have a volume many orders of magnitude larger than V_{coh}... This makes the discussion in the Letter of the effects of coherent radiation force on the bunch dynamics irrelevant." The last sentence in the quote above is not justified by the previous considerations. Indeed, for the target of the volume $V_{\mathrm{coh}} \sim \lambda\!\!\!^{-3}\gamma^2$ (whose radiation is coherent according to [1]), the ratio of the energy radiated by the bunch in one revolution to its orbital kinetic energy is given by [2] as $\Gamma_{\mathrm{fat}} \sim 1.2 \times 10^{-12} n_e \lambda_L^2/(8\pi^3\gamma^4)$, or for $n_e = 10^{24}\ \mathrm{cm}^{-3}$, $\Gamma_{\mathrm{fat}} \sim 5 \times 10^9 \lambda_L^2 \gamma^{-4}$. For a reasonable case of $\lambda_L = 10\ \mu\mathrm{m}$, $\gamma = 5$, this yields $\Gamma_{\mathrm{fat}} \sim 8$; thus, a 3 TW, 10 μm laser, capable of rotating a single electron at $\gamma = 5$, will be prevented by the coherent radiation friction from accelerating a bunch of V_{coh} ($\gamma = 5$) volume above $\gamma = 1$; this is a very significant effect. More generally, [1] is unjustifiably restrictive in limiting the size of the coherently radiating lasetron target.

SZ also state "... if the self field of the beam exceeds the laser field,... one can expect a strong perturbation of the electron motion, instability, and possible destruction of the beam. The authors..., ignore this likely beam disruption and compute a magnetic field of 10^8–10^9 G (which is an order of magnitude larger than the applied laser field)." The first sentence above is unsupported in [1]. The self-induced magnetic field at the orbit is orders of magnitude lower than the calculated (by us) magnetic field at the center of the orbit. Besides, in the worst (and apparently overly pessimistic) case of no cancellation of the Coulomb repulsion within the bunch, it will take many laser cycles for this force to stretch the electron cloud beyond its orbit [2]. As we pointed out [2], several interactions may potentially affect the lasetron; the self-field effect is one of them, although not necessarily most important.

Finally, regardless of details of lasetron operation, the major point is that the lasetron could be a laser-based source of so-far unattainably short pulses, which contain large amounts of high-energy photons capable of affecting and probing fast nuclear processes. This should not be overshadowed by legitimate discussions of the lasetron operation details. This work is supported by AFOSR.

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