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Coherence and superradiance from a plasma-based quasiparticle accelerator

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Because the brightness delivered by coherent light sources - such as free electron lasers (FELs) - grows with the interaction distance, they can be several km long (e.g., LCLS). Making FELs more compact while keeping their brightness, could open unprecedented research and applications to university-scale laboratories. Here, compact plasma accelerators could play a major role, but so far they have only produced incoherent temporal radiation, limiting their brightness and uses.

Using theory combined with PIC simulations and the Radiation Diagnostic for Osiris (RaDiO), we show that radiation emitted by a collective excitation (which we denote as a quasiparticle), such as a non-linear plasma wakefield, can generate temporally coherent superradiant light with current technology. This concept can provide temporally coherent and superradiant light from THz (including the THz gap) to the extreme ultraviolet. Photon energy control can be tailored straightforwardly, mostly by adjusting plasma density. This flexibility extends further, and brings unprecedented control over finer spectral features, such as its bandwidth, which can be essencial for applications that often require specified spectra. Akin to a single particle, these features depend on the quasiparticle velocity and acceleration, which can be adjusted via tailored plasma density profiles using experimentally proven techniques.

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