Contribution ID: **50** Type: **not specified**

Picometer-scale emittance and space charge effects in nanostructured photocathodes

Generation of ultralow-emittance electron beams with high brightness is critical for several applications such as ultrafast electron diffraction, microscopy, and advanced accelerator techniques. By leveraging the differences in work function and electronic structure between different materials, we enabled spatially localized photoemission, resulting in picometer-scale emittance from a flat photocathode. We also investigated space charge effects by measuring how the emission spot size, as measured in a photoemission electron microscope, changes with the number of electrons emitted per laser pulse. When more than one electron is emitted simultaneously, Coulomb repulsion causes a substantial broadening of the observed source size, enabling us to investigate the limitations imposed by vacuum space charge forces during pulsed photoemission. Our results highlight the potential of nanoscale photoemitters as high-brightness electron sources and offer new insights into electron correlations that emerge after ultrafast photoemission.

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