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Direct measurements of emittance growth from Coulomb scattering on neutral gas atoms in a plasma lens

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Plasma lenses are of much interest to the plasma-accelerator community as their cylindrically symmetric and large focusing gradients facilitate beam-optics control of the highly divergent beams usually associated with plasma accelerators. However, a fundamental difference between plasma-based and conventional accelerators/focusing devices is that in the former the beams propagate through matter rather than a vacuum. This invariably leads to interactions such as Coulomb scattering between the beam and plasma particles, which in turn likely leads to emittance growth. Whereas the beam sizes inside plasma accelerators are comparatively small, limiting the induced emittance growth, the situation in plasma lenses is quite different as the beam size must be larger in these devices than in the accelerators to allow collimation or focusing. In particular, in active plasma lenses beam sizes must be large to avoid driving a wake, which in turn increases the induced emittance growth from scattering. This is further exacerbated by the fact that using gases of heavier elements, which scatter more strongly than their lighter counterparts, are preferable as they produce linear focusing gradients. However, direct measurements of the induced emittance growth from Coulomb scattering has hitherto not been shown for beam and lens parameters relevant for plasma-based focusing devices. In this work we show the measurements of emittance growth from scattering in neutral (i.e. un-ionized) argon, nitrogen and hydrogen over a range of pressures. Results from a corresponding set of simulations in GEANT4 and Ocelot, which represent the experimental environment, are also outlined.

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