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Mechanisms of X-ray production in laboratory streamers

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A meter-scale (macroscopic) 1D modeling of a laboratory streamer discharge [Kochkin et al, 2016, 10.1088/0022-3727/49/42/425203] produces detached streamer systems (pilots) which are observed experimentally [Kochkin et al, 2014, doi:10.1088/0022-3727/47/14/145203]. A detached streamer system grows in both directions, so that the streamers growing towards the originating electrode (counter-streamers) collide with forward-moving streamers. This process is thought to be the source of experimentally observed x-rays [Kochkin et al, 2012, doi:10.1088/0022-3727/45/42/425202; 2015, doi:10.1088/0022-3727/48/2/025205], although the details are still not clear. The enhancement of electric field between streamers [Cooray, 2009, doi:10.1016/j.jastp.2009.07.010], with subsequent thermal electron runaway and bremsstrahlung, was suggested to be insufficient by itself for the observed x-ray production [Ihaddadene and Celestin, 2015, doi:10.1002/2015GL064623]. With the help of a new symbolic computations package, which greatly simplifies setting up finite-difference equations on rectangular grids with arbitrary boundary conditions, we perform cylindrically-symmetric modeling of a streamer collision which includes all important microscopic mechanisms of streamer propagation. We investigate the role of the electric field enhancement in x-ray production, as well as discuss other possible mechanisms, such as the self-acceleration of electrons (i.e. plasma wave effects) [Askaryan, 1965, http://www.jetpletters.ac.ru/ps/1591/article_24410.shtml].