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Statistical Coulomb interactions in multi-beam SEM

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Statistical Coulomb interactions in conventional scanning electron microscopy mostly affect the probe size via energy spread and virtual source broadening in the emitter vicinity. However, in a multi-beam probe forming system such as a multi-beam scanning electron microscopes (MBSEM), the trajectory displacement due to interactions in the whole column can give a contribution to the final probe size. For single-beam systems, this can be expressed using approximate formulae for the total trajectory displacement in a beam segment (Jansen's theory) or by integrating contributions of infinitesimally thin beam slices (the slice method). We build on Jansen's theory of statistical Coulomb interactions and develop formulae for the trajectory displacement in a multi-beam system. We also develop a more precise semi-analytical result using the slice method. We compare both approaches with a Monte Carlo simulation and show a good agreement with the results of the slice method. Finally, we discuss the implications of our results for the optical design of multi-beam SEM. In a multi-beam with probe size dominated by Coulomb interactions, an increase in the number of beamlets does not necessarily provide an increase of throughput, because the probe size is limited by the total current. Furthermore, we disprove the notion of "the fewer the crossovers — the less the Coulomb interactions" by showing the quadratic dependence of trajectory displacement on segment length.

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