Electron microscopy and trams: Towards a friendly coexistence

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State-of-the art transmission electron microscopes' (TEM) performance is suffering from a multitude of environmental disturbances like mechanical vibrations and slowly varying magnetic fields, putting stringent threshold limits on these environmental factors, e.g., ≤ 25 nT for magnetic fields [1]. At the same time choosing remote and thus "quiet" areas is typically no option, as TEM labs are traditionally placed in- or close by city centers, demanding reasonable access to public transport. Tram lines represent an efficient solution but they are DC powered, drawing 500-1000 A of current, causing large scale low-frequency, magnetic field disturbances, potentially reducing imaging- and analytical performance of TEMs, see Fig. 1a. Even though there are active and passive compensation systems at the instrument side available, they are limited in performance when it comes to strong field gradients, costly and difficult to retrofit. Similar on the tram side, battery- and ground-level power supply based systems can reduce the field emissions but they are also costly and demand specialized tramcars.
An effective and economic solution is a passive system that strongly reduces the area of the current loop produced by the catenary and the rails using a clever arrangement of a bypass cable and additional supply points on the catenary [2], see Fig. 1b. By adopting this Ansatz to the dense urban setting of Vienna with the additional implementation of a rail track mass-spring vibration isolation a maximum field of 20 nT per tram at a distance of 100 m can be achieved, see Fig. 2b. This 10–20-fold reduction compared to no compensation has been verified by extensive finite element simulations and calibration tests, see Fig. 2a.
By implementing this "Viennese" variant of a passive field reduction system for tram lines urban public transport demands no longer interfere with researchers' desire for electromagnetic quietness.

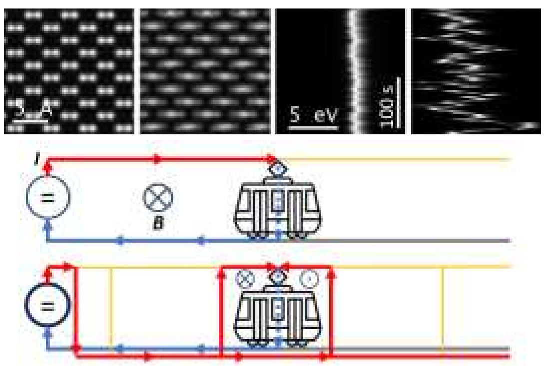
a)
b)


Fig. 1: a) TEM image distortions and energy shifts caused by near-DC magnetic fields and b) tram field reduction system principle.

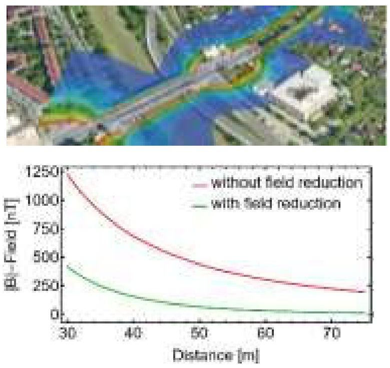
a)
b)


Fig. 2: a) 3D-FEM simulation result for the new "Linie 18" extension (blue: <20 nT), b) field distribution as a function of distance to rails.

References:
[1] Muller et al., Ultramicroscopy **106,** 1033–1040 (2006).
[2] Pieter Kruit et al., eb Elektrische Bahnen **118,** 100- 118 (2020) Heft 6.