The SPANOCH method: A key to establish aberration correction in miniaturized (multi)column systems?

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**Motivation**
- Scherzer theorem: rotationally symmetric fields suffer from spherical and chromatic aberrations.
- Within electron microscopes correctors are meanwhile state of the art.
- These correctors can not be randomly miniaturized
- not suitable for miniaturized single or multicolumn systems.
- We present a new concept:
  - provide multipole fields for correction purposes within a stack of thin sheets (plates),
  - as it could be produced by integrated fabrication methods.

**Principle**
- Holes within apertures are electron optical elements
- Superposition principle:
  - example: threefold symmetry

The SPANOCH concept
- We define ‘SPANOCH’ (sophisticated pile of apertures with non-circular holes) as a method of building a corrector out of a stack of apertures with specially shaped holes.

**SPANOCH-type hexapole corrector**
- Theoretical proof of principle: ray tracing study 2008
- Problem: Test-design not adjustable
- New design: decoupling of hexapole moments and round lenses by four adjustment voltages.
- Random access to hexapole strength
- Free of second order aberrations due to double symmetry:

**Calculation methods**
- SCOFF method used to approximate fundamental rays
- Fit of hexapole field strength \( \phi_3 \) determined by numerical analysis of plate triplet

\[
\phi_3(z) = \phi_{3A} \cdot \exp \left( -\frac{1}{2} \left( \frac{z \cdot \phi_{1C}}{\phi_{1W}} \right)^2 \right)
\]

- Adjusting wizard calculates adjustment voltage and correction power \( C_S \)
- Input/output diagram:

**Kernel of adjusting wizard**
- Use of transfer-matrix method to calculate fundamental rays in SCOFF approximation.
  - Sequence of simple lenses:
    \[
    M_{\text{lens}} = \begin{pmatrix} 1/1 & 0 \\ 0 & 1/f \end{pmatrix}, \quad M_{\text{space}} = \begin{pmatrix} 1 & s \\ 0 & 1 \end{pmatrix}
    \]
  - Davison-Calbick-formula: \( f = \frac{4V}{U_s - U_T} \frac{U_s - U_T}{U_s - U_T} \)
  - \( f = \Sigma_i M_i \vec{r}_0 \)

**Analysis of results**
- Change of parameters showed a tremendous optimization potential, e.g. distance \( a \):
  - \( a \rightarrow 0.3a \Rightarrow C_S \rightarrow 10^4 C_S \)
  - Continuous, approximately linear regulation of \( C_S \) via hexapole voltage
- Implementable global field strengths \( E < 4 \text{ kV/mm} \)

**Outlook**
- Further simulations without SCOFF approximation taking into account all contributions to \( C_S \) and to \( C_S \) will show the absolute potential of the hexapole corrector.
- These results will serve as initial adjustment for exact simulations.

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