Calculation of high order aberrations of practical multi-pole type electron optical aberration correctors using a differential algebraic method

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Abstract: With the development of ultra-high resolution electron optical instruments, the numerical calculation of aberration correctors become more and more important. As the third order aberrations are to be corrected, the fifth order aberrations become essential. The existing theory of aberration correctors including multi-pole correctors deals only with thin lens approximation [1]. Therefore, usually there are residual third order aberrations and first order chromatic aberrations. Moreover, the existing numerical calculation methods for multi-pole fields are based on multi-pole field expansion [2] and that is not accuracy enough for many multi-pole electrode structures. Therefore, it is necessary to calculate the electric and magnetic fields in 3-dimensional form. In this work, a differential algebraic (DA) method [3] for practical multi-pole correctors is presented; analytic expressions of the local electro-magnetic fields obtained by 3-D numerical computation are constructed and transformed into new forms operated in the DA calculation. Consequently, the mixed geometrical and chromatic aberrations of practical multi-pole aberration correctors up to 5th orders are calculated using the DA method and the electron optical performances of the corrector are evaluated in very high accuracy. Programs were written and tested as well. This method is expected to be applied in development of ultra-high resolution electron microscopes, electron beam lithography and IC test instruments.

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