Parametric multiplets of magnetic quadrupole lenses: application prospects for probe-forming systems of nuclear microprobe

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One of the ways for an improvement of the nuclear microprobe spatial resolution is using of more perfect probe-forming systems. The set of ion optical elements to produce the probe with sub micrometer dimensions is very limited for ion beam with energy of several MeV. The most widely used element is a precision magnetic quadrupole lens. Improvements of magnetic quadrupoles design made during last decade permitted to increase the spatial resolution of probe forming systems based on the triplets and quadruplets up to their theoretical limit. The trend toward using of systems with number of lens more than four is setting the question. Can those systems provide higher nuclear microprobe spatial resolution? The systematic investigations of parametric multiplets of magnetic quadrupole lenses were carried out to answer this issue. Here the parametric multiplet is defined as the system of magnetic quadrupoles, the ion optical properties of which are depended on the set of parameters: lenses dimensions, geometry of lenses allocation along the optic line, physical lenses properties, number of lenses and number of separated power supplies in the system. Numerical investigations were carried out. The matrizant method was used for aberrations calculation and maximum emittance method was used for the beam emittance optimization. Maximum beam current which the system can provide for a specified beam spot size on the target was used as criterion of comparison of various systems. In results have received, that using of more complicated probe forming systems with number of lenses more than four do not provide a considerable improvement of nuclear microprobe spatial resolution (considerable decreasing the beam spot on the target with sufficient ion current). However, this systems may have higher demagnifications ($D>100$) and less system length ($l<3$m) at the same time. Furthermore, some of them have specific properties which may be interesting in other ion beam applications.