Ion optical design for mass spectrometers

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Abstract

The efficient operation of mass spectrometers, since the development of the earliest instruments, has depended on the analogy between the optics of light and the 'focussing' effect of various electromagnetic fields acting on charged particles. Without the first order refocussing of the simple magnetic sector field, even modest mass resolution would be achieved only by extreme collimation of the ion beam and at a heavy penalty in sensitivity. Over the years, the increasing level of sophistication in the theoretical analysis of mass spectrometers as ion optical systems has led to real improvements in the operational performance of the instruments as analytical tools. It is now common to find mass spectrometers with non-normal incidence to the magnet, curved field boundaries, contoured magnet pole-faces, and spherical or toroidal electrostatic analysers. These and other devices are now being used to provide first and higher order focussing in both the dispersive and non-dispersive planes.

Further insight into the operation of mass spectrometers has been gained by the application of the phase space concepts originally introduced in the beam transport field of nuclear physics. The ideas of beam emittance and instrument acceptance are now widely understood and their correct matching is seen as fundamental to the ion optical design of a new instrument. Liouville's Theorem has also emphasised the relationship between mass resolution, ion transmission efficiency and instrument parameters such as accelerating potential and magnet radius.

Sensitive High Resolution Ion Micro-Probe (SHRIMP) at Curtin University in the Isotope Science Research Centre. See Compston (1996, in this issue) for the development of SHRIMP.

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