Noble Gas Mass Spectrometry in the 21st Century

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For the light gases mass resolution is key in resolving interferences and for heavy noble gases it is sensitivity that is the fundamental requirement. Optimum of mass spectrometer design therefore varies with application. While ion sources can be designed with cylindrical symmetry, minimizing mass fractionation by the absence of source magnets, and with near-perfect optical transmission, minimizing memory and maximizing sensitivity, current designs introduce other problems. The low extraction fields suffer from space charge effects with increasing pressure.

Electron multipliers eliminate mass discrimination when used in an ion-counting mode and operating at near 100% detection efficiency. However, in order to maximize sensitivity for the heavy noble gases, multiple electron multipliers are often utilized in modern designs but these usually require small multipliers, usually of the continuous dynode channel type. Small channel multipliers have restricted dynamic range and degraded by high counting rates, rendering them less suitable for the light noble gases. Multiple multiplier designs must also address the differnet isotope spacing for the different noble gases and need to be mechanically movable in conventional designs. One solution to this problem, developed by Nu Instruments, uses a pair of zoom lenses to electronically change the isotope spacing itself for each gas to match a fixed multiplier spacing, rather than vice-versa. The rapid spacing response of this instrument allows for simultaneous measurement of Ar, Kr and Xe in the 8 multiplier Noblesse instrument.

Electron multiplier of the discrete dynode type are larger and less suitable for multiple multiplier designs leaving these to small channel multipliers with limited dynamic range, less suited got the light gases. GVI has developed sensitive refridgerated low-noise amplifiers for direct Faraday detection, largely filling the gap between the restricted range channel multipliers and conventional Faraday detectors. Moreover, these incorporate switchable Faraday/multiplier detection at each isotope position, opening up high sensitivity multiple detector designs for light noble gas applications.

Chemistry is a problem even for noble gases. Bathed in an atmosphere of chemically reactive gases, we generally think of noble gases as inert but, put in an untra-high vacuum environment under non-equilibrium conditions, noble gases do form chemical compounds that need to be understood and properly corrected for elimination of isobaric interferences. We will discuss noble gas hydrides and anomalous isotope effects sometimes observed but not yet understood. We will also review and compare various new instruments, their strengths, weaknesses and paths toward future instruments. as well unique approaches, such as resonance ionization.