

The Gated Electrostatic Mass Spectrometer

Fred A. Herrero

NASA Goddard Space Flight Center, Code 553, Greenbelt, MD

This talk describes the path taken by the author in going from electrostatic energy analyzers to a new type of time-of-flight mass spectrometer offering several advantages. We discuss the parallel plate electrostatic analyzer (PPA), used perhaps since the beginning of ion/electron optics, mostly as an auxiliary device in charged particle spectrometers. Its focusing properties for 90° and 60° total deflections made it desirable for some limited applications and in a more recent application a 90° PPA was modified to provide focusing of magnetosphere electrons over a field of view of $30^\circ \times 30^\circ$. The main disadvantage of the conventional PPA and other conventional energy analyzers is the large voltage required between the analyzer plates to select the energy of transmitted particles. This becomes a serious issue in space plasma physics investigations because the energies of interest for ions and electrons typically reach or exceed 40 keV. Limiting the deflection angle to small values offers space plasma investigators an energy analyzer that reaches 50 keV with 2 kilovolts instead of the 7 kilovolts required for the best conventional analyzer solution. This small deflection energy analyzer (SDEA) provides the low voltage advantage without reduction in field of view, energy resolution, and sensitivity. One useful property of SDEA is the simple geometrical shape that enables distribution of multiple SDEAs in two-dimensional arrays to increase sensitivity while keeping energy resolution constant. Low-energy experiments could also benefit from the SDEA approach to the PPA - very small voltages (usually less than 5 volts) are required for low energy (< 30 eV) operation in wind and temperature spectrometers for ionosphere-thermosphere investigations. At that point in the development of SDEA there was no motivation to use it in a mass spectrometer. But Lunar exploration changed that with a special challenge: Ions sputtered by solar wind ions from the surface of the Moon may be used to obtain the distribution of minerals on the Lunar surface. However, expected sputtered ion fluxes are so low that a mass spectrometer with an aperture of about 10 cm^2 is required. Furthermore, in order to make the spectrometer compatible with likely spacecraft, that aperture must fit on a $2 \times 2 \text{ ft}^2$ ($60 \times 60 \text{ cm}^2$) footprint. This provided the motivation for the Gated Electrostatic Mass Spectrometer (GEMS) that will be described in full detail in this paper, showing some of the laboratory data obtained thus far. We will see how GEMS arrays may be used to provide relatively high sensitivity with high mass resolutions.