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Ion Focusing in Cycloidal Mass Spectrometers

Dedicated to
Professor Mieczysław Subotowicz
on occasion of his 65th birthday.

The first cycloidal mass spectrometer has been constructed by Bleakney and Hipple yet in 1938 [1]. This type of m/e analyzer exploits the perfect ion focusing property of the crossed uniform electric and magnetic fields. However, it never becomes a popular, commercially available instrument, due to difficulties in the compensation of aberration of every real arrangement.

A few years experience with a new design cycloidal mass spectrometer for precise measurement of isotope ratios [2] has led us to simplification of the ion focusing procedure in this type spectrometers.

Departures from the perfect point-to-line focusing properties of the crossed E and B uniform fields are inherent for real instruments. For the following important reasons the ions may be focused off the plane of the collector slit: (1) inhomogeneity of the magnetic field, (2) divergence of the ion beam due to space charge interaction, (3) displacement between the planes of entrance and collector slits.

The exact positioning of the linear ion image on the resolving slit may be done by differing the electric fields which act on the ions traveling in the space below and above the ground plate, E_1 and E_2 in Fig. 1.

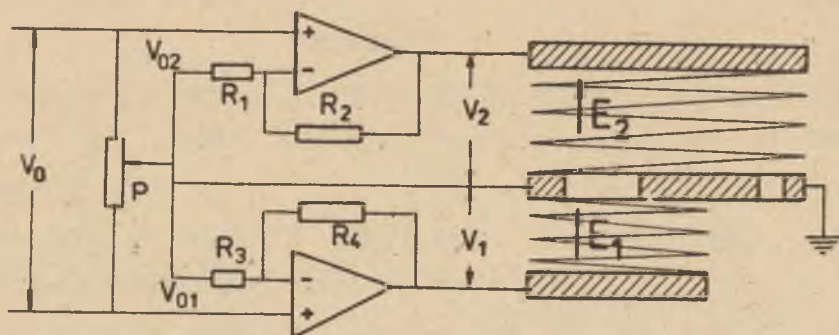


Fig. 1. A simplified diagram of a cycloidal mass spectrometer with a resistive wire between plates protecting the homogeneity of the electric field and the electronic system for ion focusing on the resolving slit.

In the ideal case, if $E_1 = E_2 = E$, the ions are focused in the plane of the entrance and resolving slits. If this is not the case, then the ratio E_2/E_1 could be modified by differing the ratio of appropriate voltage V_1/V_2 at a constant total voltage $V_1 + V_2 = E_1 d_1 + E_2 d_2$, where d_1 and d_2 are distances between conducting plates producing fields E_1 and E_2 . In this way a displacement of the ion image can be easily eliminated.

The schematic diagram of the electronic system is also shown in Fig. 1. The ratio V_2/V_1 can be adjusted by means of potentiometer which divides the voltage V_0 to input voltages V_{01} and V_{02} . The output voltages, V_1 and V_2 should be exactly

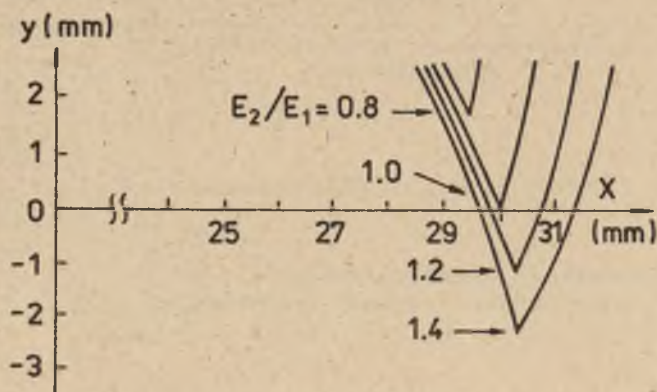


Fig. 2. The position of the focus for the ion beam of $m/e = 3$ in the mass spectrometer for stable isotope analysis of hydrogen as a function of E_2/E_1 ratio.

proportional to the input voltages with the same amplification factor, i.e. at $R_2/R_1 = R_4/R_3$. The computer tracing of the ion trajectories in the D/H ratio mass spectrometer, the final parts of which are shown in Fig. 2, proves that the focus departs from the ideal position if the ratio E_2/E_1 differs from the unity. One may see from Fig. 1, however, that the departures along y-axis are more significant than those along x-axis. For this reason a precise tuning of the mass spectrometer can be done by using of two potentiometers only: one for adjusting V_0 (for selecting m/e ratio) and another for adjusting V_2/V_1 , which enables to focus the ion beam on the collector slit. If the collector slit is very narrow then the adjustment of V_0 value should be repeated.

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REFERENCES

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- [2] Halas S.: *Int. J. Appl. Rad. Isotopes* 1987, 12, 957-960.

