Ultra-high resolution, high-energy collision induced dissociation

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The mass resolution of a TOF mass spectrometer is directly proportional to its total flight path length. Thus, the maximum flight path that can be achieved in a typical laboratory instrument is of the order of a few meters. In order to overcome this fundamental problem, it is necessary to store the ions in a closed orbit, and to pass the ions around the same orbit many times. In this way, the path length can be easily extended ad infinitum. However, if the ion beam diverges in both time and space, then both the mass resolution and the ion transmission are compromised as the number of cycles increases. To avoid this, we need to design an ion optical system that gives 'perfect focusing', where the ions return to their point of origin in the system, in both time and space. We studied the ion optics of a multi-turn TOF mass spectrometer consisting of electric sector fields, and found three ion optical systems that achieve the 'perfect focusing'.

One of these proposed TOF systems, the 'MULTUM Linear plus', was constructed as a laboratory model for the COSAC project of the ROSETTA space mission [1]. It consists of four cylindrical electrostatic sectors and 28 electric quadrupole lenses. It was experimentally demonstrated that mass resolution increased according to the number of ion cycles through the ion optical system. A mass resolution of > 350000 was achieved after 500 cycles.

Another multi-turn TOF mass spectrometer, the MULTUM II, was also developed [1]. The new instrument consists of only four toroidal electric sectors. We demonstrated that mass resolution increases according to the number of cycles as well. MALDI ion source was attached to the MULTUM II for analysis of biomolecules. A mass resolution of > 70000 was achieved for Angiotensin I (m/z 1296.7).

Recently, various types of mass spectrometers based on the MULTUM II technology are developing, for example, a tandem mass spectrometer 'MULTUM-TOF/TOF' [2], a stigmatic type imaging mass spectrometer 'MULTUM-IMG' [3], and portable mass spectrometers of high mass resolving power 'MULTUM-S' series [4].

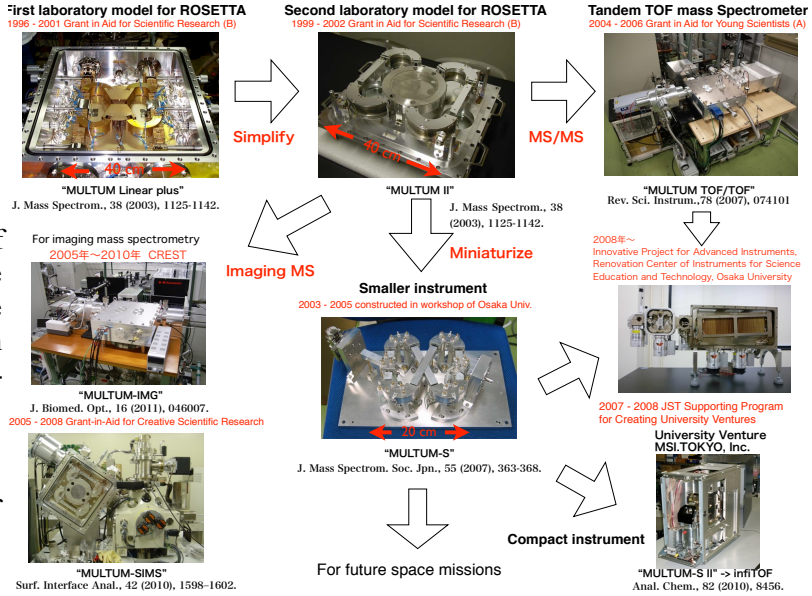

Figure 1. Development history of MULTUM

References

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