Quadrupole Ion Trap Technology:
Historical Notes

Vladimir M. Doroshenko

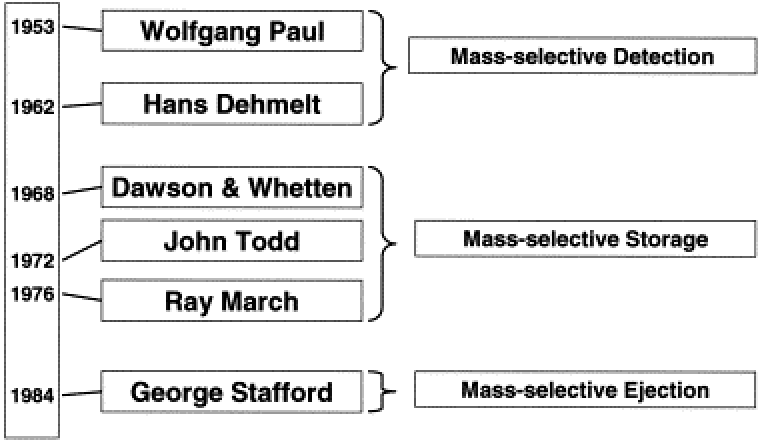
MassTech User Meeting

June 1, 2025

The 1989 Nobel Prize in Physics

Professor Wolfgang Paul, University of Bonn, Germany and
Professor Hans G. Dehmelt, University of Washington, USA
have introduced and developed the ion trap technique which has made it possible to study a single electron or a single ion with extreme precision

Wolfgang Paul



Stafford, G. (2002). Ion trap mass spectrometry: A personal perspective. *J. Am. Soc. Mass Spectrom.* 13(6), 589–596

MASSTECH

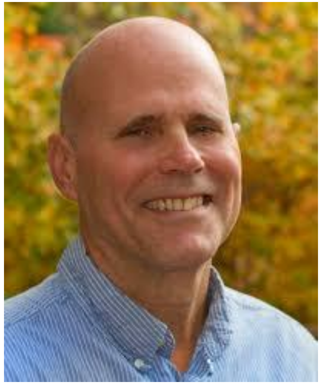
1990s: Ion Trap Research Groups

Graham Cooks

Perdue University

Scott McLucky

Perdue University



Garry Glish

University of North Carolina at Chapel Hill

Bob Cotter

The Johns Hopkins University

MASSTECH

Russian MS Interest Group at ASMS

J. Am. Soc. Mass Spectrom. (2019) 30:2178-2182
DOI: 10.1007/s13361-019-02281-9

Check for updates

COMMENTARY

The Russian Mass Spectrometry Interest Group at ASMS: Over 20 Years of Science and Water Polo

Yury O. Tsybin,[1] Pavel V. Bondarenko,[2] Viatcheslav B. Artaev,[3] Roman A. Zubarev,[4] Catherine E. Costello[5]

[1]Spectroswiss, 1015, Lausanne, Switzerland
[2]Amgen, Thousand Oaks, CA 91320, USA
[3]LECO Corporation, St. Joseph, MI 49085, USA
[4]Karolinska Institutet, SE-171 77, Stockholm, Sweden
[5]Boston University School of Medicine, Boston, MA 02118, USA

Abstract. The Russian Mass Spectrometry Interest Group (RMSIG) emerged in 1998 during the annual ASMS meeting in Orlando, FL. The original goal of the group was to help assimilating mass spectrometrists from the former Soviet Union countries into the West. Following the fulfillment of this objective, the RMSIG continues nowadays as a social and scientific club of 200+ members, to the benefit of mass spectrometry at large. Herein, we share with you the tale of the RMSIG: its history, accomplishments, and present days activities—all in a close relation to ASMS.

Keywords: Russian Mass Spectrometry Interest Group, ASMS, Water polo, Singing

Received: 17 June 2019/Accepted: 27 June 2019/Published Online: 7 August 2019

Figure 1. At the 48th ASMS Conference (Long Beach, CA, June 2000). The early days of the Russian MS Interest Group. Standing: Raznikov, Mamyrin, Shainskaya, Gusev, Doroshenko, Artaev, Mordehai, Tolmachev, Berkut, Makarov. Sitting: Podtelejnikov, Kiselar, Taranenko, Loboda, Dodonov, Moskovets, Shevchenko, Bondarenko, Chernushevich, Laiko, Nesaty, Kovtoun, Fishman and others.

Victor Talrose

Father of Russian MS

Boris Mamyrin

Reflectron TOF MS

Alexander Dodonov

Orthogonal reTOF MS

Lidia Gall

ESI MS

Eugene Nikolaev

FT-ICR MS

Ernst Sheretov

Ion Trap MS

Russian MS Interest Group at ASMS: Stretched Ion Trap

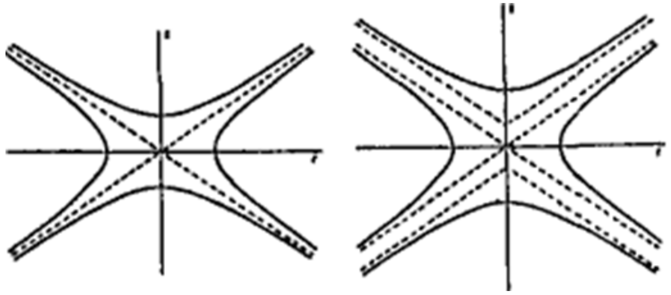
1992

The 40th ASMS Conference on Mass Spectrometry and Allied Topics

The Paul Ion Trap Mass Selective Instability Scan: Trap Geometry and Resolution

J. Louris, J. Schwartz, G. Stafford, J. Syka, and D. Taylor
Finnigan MAT, 355 River Oaks Parkway, San Jose, CA 95134-1991

Not only does the Paul Ion trap not need to be built to exacting tolerances when used as a mass spectrometer in the mass-selective instability mode, we have found that performance is actually enhanced if the geometry of the trap is grossly distorted. Although it is not widely recognized, all of the commercially produced traps have had a distorted geometry. In particular, the resolution is consistently better in traps with a distorted geometry. Since a number of groups are now studying the details of ion motion in the trap, it is important that the actual geometry of the commercially-produced trap be widely known: the Finnigan trap has electrodes whose shape is the "theoretical" shape determined by r_0 = 10.00 mm and z_0 = 7.07 mm. However, the three electrodes are not held in the relative position of a "theoretical" trap. Instead, the end electrodes are spaced such that the distance of each to the center of the trap is 7.83 mm (instead of the theoretical 7.07 mm). This "stretched" geometry is shown schematically in Figure 1.



1996

Anal. Chem. **1996,** *68,* 4257−4263

Resonance Ejection from the Paul Trap: A Theoretical Treatment Incorporating a Weak Octapole Field

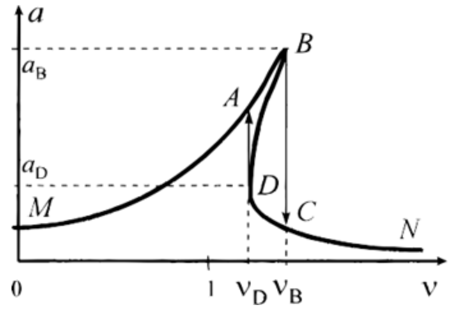
Alexander A. Makarov

HD Technologies Ltd., 95-98 Atlas House, Simonsway, Manchester M22 5PP, U.K.

In response to the growing experimental evidence of the importance of nonlinear phenomena in ion trap operation, a new theoretical model of ion ejection is developed. The pseudopotential well approximation for forced ion oscillations in an ion trap under the conditions of ion−molecule collisions is modified to include octapole perturbations on the quadrupole field. Ion ejection is investigated using the first-order Mitropol'skii asymptotic method for both infinitesimal and finite scan rates. It is shown that the combined action of collisional damping and nonlinearity distorts the resonance curve in such a

workers[10] by incorporating a sinusoidal external driving force and viscous damping due to collisions with gas. Within their model, the ion resonance ejection line shape was derived as a function of scan rate and collisional relaxation time. Later, this theory was extended by Arnold et al.[11] to account for the amplitude dispersion at ejection.

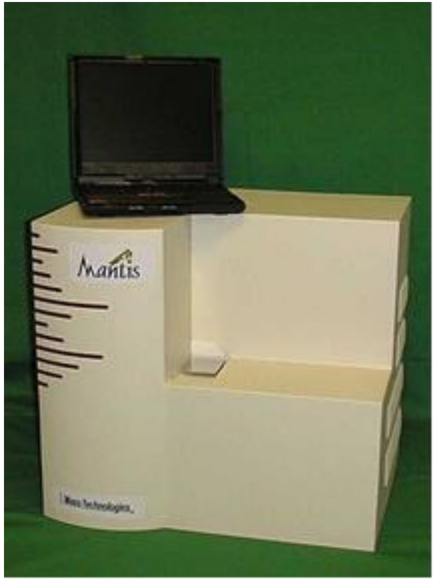
Although these newer theories predict correctly the increase of mass resolution with decreasing scan rate, they still underestimate the experimental results by a factor of >10! This is rather unusual as, for mass spectrometers, experimental mass resolution is normally much lower than the theoretically predicted one. In



MASSTECH

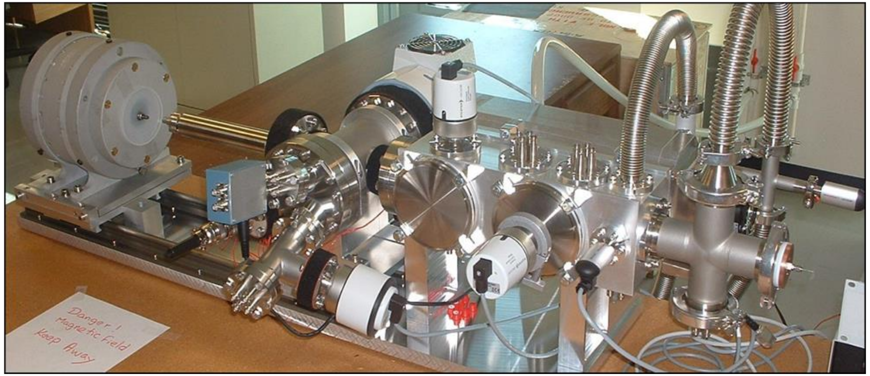
Earlier Developments

2000



MANTIS: UV/IR End-cap Reflectron TOF-MS

2004-2008

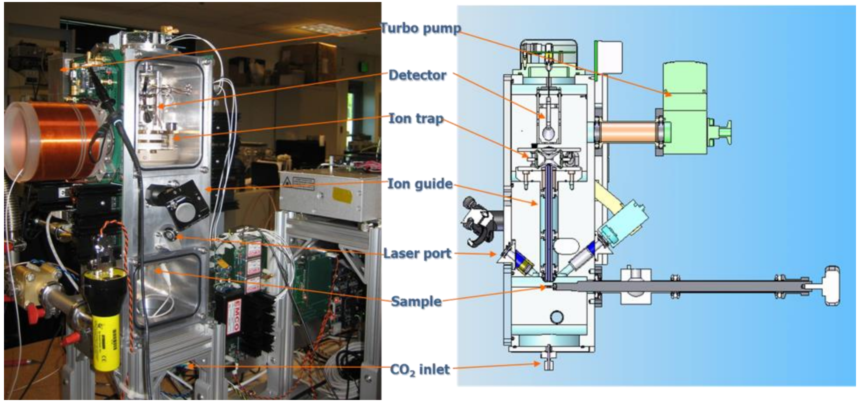


API Permanent Magnet FTICR-MS

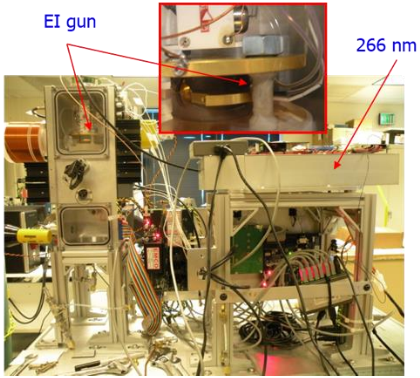
ESA ExoMars Project: Mars Organic Molecule Analyzer (MOMA)

2007-2009

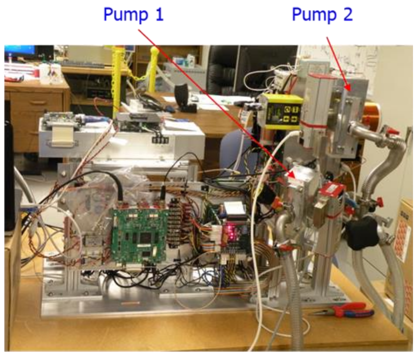
A Miniature Ion Trap Mass Spectrometer Coupled to a Laser for the Detection of Organics on Mars



P1 prototype with LDI source



P2 with EI and LDI sources



P3 with differential pumping

MT Explorer 100: Field-deployable API Ion Trap MS

2011

Features:
3-section vacuum chamber
5 pumps included
He buffer gas (lecture bottle)

Mass range: 30-2000 Da
Mass resolution: 0.5 Da
MS & MS/MS modes
Pos & Neg ion modes
Weight: 35 kg
Size: 48x43x42 cm
Power: 500 W

MASSTECH

MT Explorer 50: Field-deployable API Ion Trap MS

2012

Features:
2-section vacuum chamber
3 pumps included
H2 buffer gas (MH cartridge)
Ion sources: ESI, APCI, AP-MALDI, DART

Mass range: **35-2000 Da**
Mass resolution: 0.5 Da
MS, MS/MS & b-MS/MS modes
Pos & Neg ion modes
Weight: **35 kg**
Size: **30x43x50 cm**
Power: **300 W**

MT Companion: Portable μGC Interfaced to Ion Trap MS

2019

Features:
1-section vacuum chamber
2 pumps included
He buffer gas (GC mobile phase)
EI ionization
MEMS μGC
Battery operation

Mass range: **35-500 Da**
Mass resolution: 0.5 Da
MS mode
Pos ion mode
Weight: **10 kg**
Size: **10 L**
Power: **~100 W**

MT Explorer 30: Portable API Ion Trap MS

2022

Features:
2-section vacuum chamber
3 pumps included
H2 buffer gas (MH cartridge)
Battery operation capable
Ion sources: ESI, AP-MALDI, DSAP, LDSAP

Mass range: 30-2000 Da
Mass resolution: 0.5 Da
MS, MS/MS & MS^3 modes
Pos & Neg ion modes
Weight: 17 kg
Size: 22x31x33 cm
Power: 200 W

Acknowledgements

MassTech

Alexander Misharin
Andrey Vilkov
Victor Laiko
Konstantin Novoselov
Eugene Moskovets
Vadym Berkout
Berk Oktem
Chaminda Gamage
Phillip Tan
Maciej Bromirski
Timothy Lippa
Sang Min Lee
Alex Achey

Robert J. Cotter - JHU
Luan Becker - JHU
Timothy Cornish - JHU
Theresa Evans-Nguyen - USF
Michael Gorshkov - RAS
Peter Hesketh - Georgia Tech
Roman Zubarev - Karolinska Inst
Brian Musselman - IonSence
Ernst Sheretov - RAS