ACS EARTH AND SPACE CHEMISTRY

http://pubs.acs.org/journal/aesccq

Editorial

Harold Linnartz: A Life in the Molecular Universe

Published as part of ACS Earth and Space Chemistry special issue "Harold Linnartz Festschrift".

Cite This: *ACS Earth Space Chem.* 2025, 9, 1960−1963

Read Online

This special issue of *ACS Earth and Space Chemistry* of the American Chemical Society is dedicated to our esteemed colleague Harold Linnartz (Figure 1) who passed away unexpectedly on December 31, 2023. Harold held the Chair for Laboratory Astrophysics at Leiden Observatory, Leiden University, The Netherlands, where he was appointed in 2005. He was a world leader in laboratory studies of gaseous and icy molecules in interstellar space. The contributions in this special issue reflect the breadth and interests in the scientific work Harold has pursued over his career. It is an homage to his scholarship and his desire to understand fundamental molecular physics of great relevance to molecular physics, in particular, molecular astrophysics.

Figure 1. Harold Linnartz.

■ SCIENTIFIC CAREER

Harold Linnartz was born in 1965 in Heerlen, The Netherlands, where he also grew up. He received a doctoral degree (the equivalent of the current master's degree) in experimental physics at the University of Nijmegen in The Netherlands in 1989. After a brief stint as a junior researcher at the Max Planck Institute fur Strömungsforschung in Göttingen, he returned to the University of Nijmegen as a graduate student in the Molecular and Laser Physics group of the Physics Department. Harold Linnartz graduated on a thesis entitled, "Infrared and Far Infrared Spectroscopy of Transient Species", in 1994, under the supervision of Leo Meerts, Hans ter Meulen, and Jörg Reuss. Already during his Ph.D. studies in Nijmegen, he was very interested in astronomy, giving tutorials in astrophysics, setting up two astrophysics experiments in the laboratory classes of the department, and playing an active role in the local astronomical society of Nijmegen.

After two years as a postdoctoral fellow at the Institute of Applied Physics of the University of Bonn, Harold joined Professor John Maier's group at the University of Basel as a Senior Researcher, starting a broad career in astrochemistry with studies on the electronic spectra of transient species, in particular, in relationship to the Diffuse Interstellar Bands. In 2002, Harold Linnartz wrote his Habilitation in Physical Chemistry entitled, "High resolution spectroscopy of ions, radicals and ionic complexes in the gas phase", demonstrating that he was ready to transition to a leadership role with strong academic and mentoring capabilities.

Harold Linnartz returned to The Netherlands on a VIDI, part of the Dutch Research Council (NWO) Talent program, and he joined the Laser Centre at the Vrije Universiteit in Amsterdam as a Senior Researcher. Harold joined Leiden Observatory at Leiden University as an Associate Professor in 2005 and was also appointed as the director of the Laboratory for Astrophysics. In 2008, he was appointed as a Professor by Special Appointment at the Laser Centre of the Vrije Universiteit in Amsterdam on a Chair for Molecular Laboratory Astrophysics. In 2009, Harold Linnartz was awarded a VICI grant in NWO's Talent program recognizing his stature as an outstanding senior researcher who has successfully demonstrated the ability to develop his own innovative lines of research. In 2011, he was appointed as a Full Professor at Leiden University on a Chair for Laboratory Astrophysics.

Harold Linnartz was very active on the national and international astronomical level. In particular, he acted as the coordinator of the Laboratory Astrochemical Surface Science In Europe (LASSIE) Network, a Marie Curie Innovative

Published: August 21, 2025

https://doi.org/10.1021/acsearthspacechem.5c00212
ACS Earth Space Chem. 2025, 9, 1960−1963

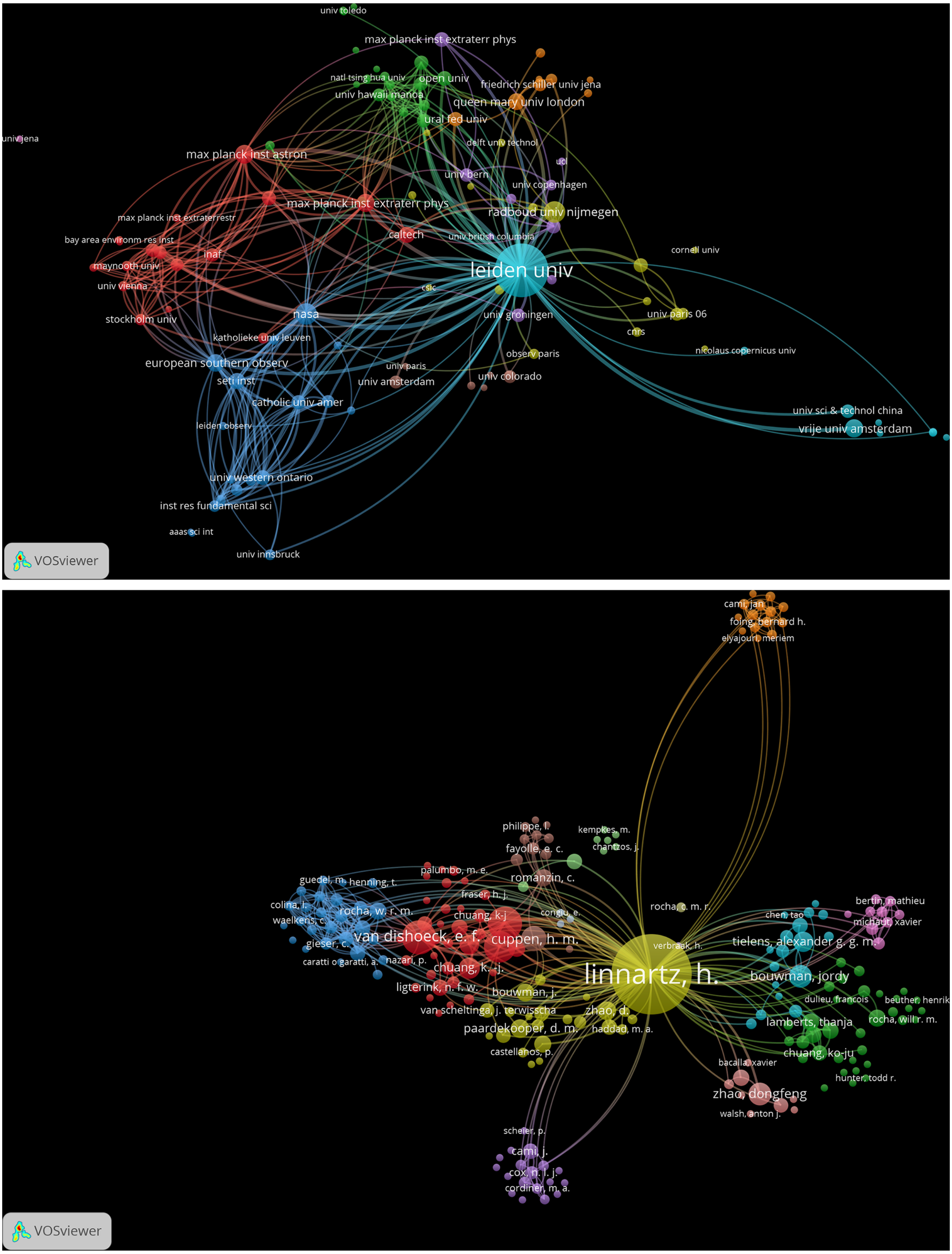

Figure 2. continued

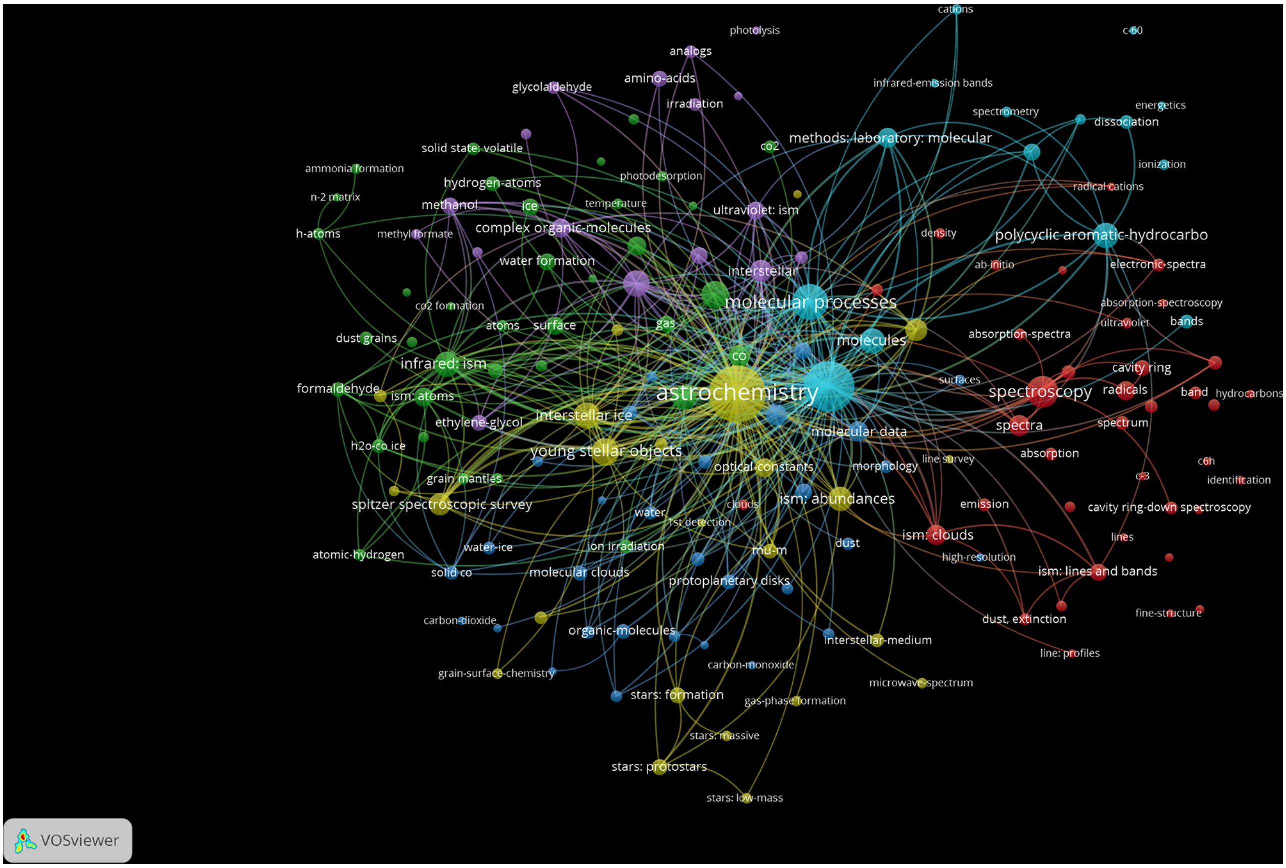

Figure 2. Science map representation of Harold Linnartz in the molecular universe. Top panel: Harold's connection to institutes in the world ranges from institutes in The Netherlands − (notably, Leiden Observatory, the FELIX laboratory, and the astrochemistry group at the Radboud University in Nijmegen and the molecular spectroscopy group at the Vrije Universiteit in Amsterdam) to a wide range of institutes in Europe − (notably, universities in Paris, the Max Planck Institute for Astronomy in Heidelberg, and Queen Mary University in London) to institutes in North America (notably, the University of Hawaii and the University of Western Ontario). Middle panel: Harold's connection to researchers in the field includes many former students and postdoctoral fellows as well as experts in the field. Bottom panel: Harold's connection to topics in the field of astrochemistry includes molecular processes involved in the chemistry of interstellar ices, infrared spectroscopy of low-temperatures ices, spectroscopy of simple radicals in the visible region of the spectrum, and infrared spectroscopy of polycyclic aromatic hydrocarbons. Through these connections, Harold contributed greatly to our understanding of the molecular inventory of space, in particular, in regions of star and planet formation, through the analysis and interpretation of, i.e., Dicuse Interstellar Band spectra and Spitzer infrared spectra, as well as to the processes involved in their formation and evolution. The many students and postdoctoral fellows that he has trained over the years will ensure that his legacy will live on.

Training Network under the Seventh Framework Programme for Research of the European Union, which combined many of the leading astrochemistry groups on interstellar ices. He was also coordinator of the solid state component of the Dutch Astrochemistry Network and a board member of the subdivision of the International Astronomical Union, "Laboratory Astrophysics", a board member of the "High Resolution Molecular Spectroscopy" symposium, and a board member of the *Journal of Molecular Spectroscopy*.

■ SCIENTIFIC CONTRIBUTIONS

Figure 2 maps Harold Linnartz's connection to the field of molecular astrophysics. We readily recognize the institutes to which Harold has been connected over his career: Radboud University, Basel University, the Vrije Universiteit in Amsterdam, and Leiden University and close colleagues at those institutes. His students and the landing places of those who continued in academia also stand out. In addition, over the years, he has been involved in scientific studies with researchers at many of the leading astrochemistry institutes in the world as illustrated by the high density of international nodes. He was always open to collaborations and ready to contribute his insights into experimental techniques and molecular physics and chemistry.

Harold Linnartz had in-depth expertise in designing, building, and commissioning laboratory setups and applied this to a wide array of topics in astrochemistry (Figure 2). As a graduate student at Radboud University, Harold started off in the field of molecular spectroscopy of gas phase molecules, i.e., radicals, and he continued to cherish this interest throughout his career with dedicated programs at subsequent "stops" at Basel, Amsterdam, and Leiden. At Basel, Harold was enticed by the century-old problem of the Diffuse Interstellar Bands. These visible absorption bands were discovered in photographic stellar spectra in the 1920s, and now some 500 absorption bands have been catalogued. These visible absorption bands are due to electronic transitions in molecules, and likely radicals and/or ions are involved. While specific identifications have proven to be challenging, five of the DIBs have been unequivocally identified with the buckyball cation, C_{60}^{+}, by John Maier's group in Basel. Soon thereafter, in May 2013 Harold acted as chair of the 297th Symposium of the

https://doi.org/10.1021/acsearthspacechem.5c00212
ACS Earth Space Chem. 2025, 9, 1960−1963

International Astronomical Union, held in Noordwijkerhout in The Netherlands, on the topic of the Diffuse Interstellar Bands, bringing together more than 100 astronomers and molecular spectroscopists from 21 countries. After the identification of the C_{60}^+ lines in Basel, Harold involved himself with a group in Innsbruck to further verify the findings in independent laboratory checks.

Simple carbon chain species have always been considered as promising candidates, and many of the relevant spectroscopy studies on such carbon chains at Basel University have used a very sensitive technique based on cavity-ring-down spectroscopy in a pulsed slit nozzle, incorporating a discharge in a high-pressure supersonic expansion developed by Harold Linnartz when he was associated with this institute. Besides their use for the molecular inventory of space, these studies are also particularly relevant for our understanding of the molecular physics of such species.

At the VU Laser Centre Amsterdam, Harold further explored the possibilities of combining the slit-jet plasma pulsed source of carbon chain molecules with cavity-ring-down spectroscopy over a broad range of the spectrum from the near-IR to visible and ultraviolet wavelengths. An extensive study of the C_6H chain was performed, analyzing the Renner–Teller effect in the ground state, and the sequence of excited vibronic states. A laboratory study of various bands of the C_3 molecule, starting from the 405 nm comet band including higher vibrations, led to the identification of these features in a translucent cloud observed with the VLT. In all of these studies, rotationally resolved spectra were measured for both ^{12}C and ^{13}C, assisting in unraveling the structure of the molecules. Deuterium labeling and symmetry rules helped to assess the nonlinear geometric structures of isomers of C_9H_3 and $C_{11}H_3$.

When appointed in Leiden, Harold Linnartz continued programs on the infrared spectroscopy of interstellar ices, in support of observing programs with the Spitzer Space Telescope, through, e.g., in-depth studies of mixtures of NH_3, CH_3OH, and HCOOH with H_2O. Harold recognized the importance of detailed infrared spectra for comparison to interstellar ice spectra, and he envisioned a broad database of such relevant spectra for this purpose. While there is little direct glory associated with constructing such a database, it is of great importance for the field of molecular astrophysics. To this end, Harold initiated an extensive program of spectroscopy of a wide array of mixtures of organics in H_2O ices in preparation for the James Webb Space Telescope. The results of this "labor of love" have been assembled in the Leiden Ice Database for Astrochemistry (LIDA, https://icedb.strw.leidenuniv.nl/) and are now the basis of many James Webb Space Telescope (JWST) ice analyses. Unfortunately, Harold only got to enjoy the first fruits of his vision for the field.

In Leiden, Harold Linnartz took charge of a number of dedicated experiments on the chemistry involved in interstellar ices using ultra-high-vacuum surface science setups. The initial studies focused on the diffusion and reaction of atomic hydrogen on carbon monoxide and molecular oxygen ice surfaces, illustrating the importance of hydrogenation reactions on ice surfaces under astrophysically relevant conditions. He also continued studies on the role of ice photolysis by far-ultraviolet photons. In recent years, Harold successfully directed the studies in the laboratory to reactions of simple radicals such as formyl as the first step in the formation of organic molecules such as glycolaldehyde.

In Leiden, Harold also supported studies on the photochemistry of polycyclic aromatic hydrocarbon (PAH) cations in an ion trap. These studies revealed that large PAH cations are quickly stripped of all of their hydrogen atoms before the loss of dicarbon units commences. The mass pattern of the carbon clusters reveals the presence of magic numbers, reflecting the higher stability of their carriers. The pattern of these magic numbers is very similar to the magic numbers encountered in the processing of fullerenes. This supports a top-down chemistry model for interstellar complexity where large species formed in the outflows of carbon-rich asymptotic giant branch stars are stripped to carbon clusters that break down to smaller carbon moieties that isomerize to pure carbon cages and eventually fullerenes.

Over the years, Harold trained many graduate students and postdoctoral fellows in experimental astrophysics (Figure 2). Many of these continued in science with postdoctoral positions at leading astrophysical laboratories in, e.g., France, the United Kingdom, the United States, and China, and then more permanent positions in academia. Many also pursued a career outside of astronomy in an industrial setting. All of them profited from much of Harold's rigorous training in experimental techniques and scientific acumen. Together, they provide a lasting legacy of Harold's contribution to science and society at large.

In 2018, Harold Linnartz became the director of education at Leiden Observatory, where he was responsible for the bachelor's and master's education program. During this period, which included the challenging COVID years, he guided with passion one of the largest education programs in astronomy. Harold always kept a vivid eye on the interests of individual students. He realized that a university is a big place but that he could play crucial roles in the lives of individual students. Many of them are still grateful for his help.

■ THIS VOLUME

The papers in this special issue were submitted upon a broad call to the astrochemical community, and the large response is a testament to Harold's standing in the community. The diversity of topics covered by these manuscripts attests to the broad scientific interest exhibited by Harold over his career. All manuscripts were peer-reviewed within the well-established standards of the American Chemical Society. Together, they present an impressive crosscut of the field and the current status of molecular astrophysics.

The papers in this special issue have been organized into three themes that align well with Harold's scientific interests: spectroscopy, physics, and chemistry of interstellar gaseous species; spectroscopy, physics, and chemistry of interstellar ices; and spectroscopy, physics, and chemistry of interstellar polycyclic aromatic hydrocarbon species.

Alexander Tielens
Wim Ubachs orcid.org/0000-0001-7840-3756

■ AUTHOR INFORMATION

Complete contact information is available at:
https://pubs.acs.org/10.1021/acsearthspacechem.5c00212

Notes

Views expressed in this editorial are those of the authors and not necessarily the views of the ACS.

https://doi.org/10.1021/acsearthspacechem.5c00212
ACS Earth Space Chem. 2025, 9, 1960−1963