Transactions IAU, Volume XXXA
Reports on Astronomy 2015-2018
Maria Teresa Lago, ed.

DOI: 00.0000/X000000000000000X

COMMISSION H2 **ASTROCHEMISTY**

PRESIDENT **Paola Caselli**
VICE-PRESIDENT **Jes Jørgensen**
PAST PRESIDENT **Edwin Bergin**
ORGANIZING COMMITTEE **Helen J. Fraser, Wolf Dietrich Geppert, Dariusz C. Lis, Karin I. Öberg, Dmitry A. Semenov**

TRIENNIAL REPORT 2021-2023

1. Background

Astrochemistry is a relatively young discipline that has now transformed itself into remote-sensing astrophysics. Although the identification of the first molecule in the interstellar medium took place more than 80 years ago, it is only in the past few decades that the concerted efforts of observational and theoretical astronomers, theoretical and experimental chemists have catapulted Astrochemistry into a quantitative discipline, with a large impact on a diverse set of astrophysical fields. Astrochemistry is fundamental to our understanding of the physical/chemical structure and dynamical evolution of the interstellar medium in the Milky Way and local, as well as high-redshift galaxies, star-forming regions, protoplanetary and planet-forming disks, of planets, exoplanets, and evolving stellar systems including our own. This is all possible thanks to an accurate knowledge of molecular spectra and the great progress made in understanding paths to the formation and destruction of the observed molecules. These theoretical and experimental efforts have enabled us to unravel gas kinematics and characterize different parts of the observed region using appropriate molecules and transitions. Accurate kinematics studies using molecular lines have, for example, recently allowed the detection of young planets embedded in their natal circumstellar disk.

Commission H2 Astrochemistry came into existence at the 2015 General Assembly following a proposal to the IAU from Tom Millar, Paola Caselli, and Satoshi Yamamoto, having previously existed as a very active Working group since 1984. Tom Millar (UK) was the founding President.

2. Developments within the past triennium

2.1. *Astrochemical Frontiers 2021*

After the success of the virtual conference Astrochemical Frontiers 2020, Quarantine Edition, in 2021 the H2 Committee organized a similar event: Astrochemical Frontiers 2021, Quarantine Edition 2 (https://sites.google.com/view/astrochemical-frontiers-2021). For the 2021 conference, we received almost 400 registrations, and more than 100 abstracts were submitted. The conference was a success, as many young scientists had the opportunity to present their recent results and participate in discussions via a Slack channel. Besides gender and geographical balance, we also made sure to have talks from the different communities (observations, experiments, theory), to reflect the interdisciplinary nature of Astrochemistry.

2.2. *From Clouds to Planets II: The Astrochemical Link*

The current H2 Commission President (Paola Caselli) Chaired a hybrid conference dedicated to Astrochemistry, *From Clouds to Planets II: The Astrochemical Link*, with 100 attendees, in Berlin (3-7 October 2022). Among the attendees, there were experts on interstellar clouds, protostars, protoplanetary disks, exoplanets, and the Solar System. A significant fraction of attendees were students and young researchers, who expressed their enthusiasm for finally participating in a conference (after the pandemic) and for learning so much about the various fields all linked by astrochemistry. In fact, introductory lectures were organised at the beginning of each session. Information about the conference can be found at the website: https://events.mpe.mpg.de/event/12/.

2.3. *The 2023 Kavli-IAU Astrochemistry Symposium*

In 2021, the H2 Commission also prepared and submitted the proposal for the VIII Kavli-IAU Astrochemistry Symposium (From the First Galaxies to the Formation of Habitable Worlds; https://www.iau.org/science/meetings/proposals/loi/2023/2137/), continuing the tradition of about six years interval between IAU Astrochemistry Symposia. Support letters from IAU Divisions B, F, J, and Commission F3 were received. The proposal was accepted and, again, it was a success.

The eighth Kavli-IAU Symposium on Astrochemistry has allowed the ever-growing astrochemical community to meet and discuss recent achievements and future progress. After Spain (2011) and Chile (2017), we had a 4.5-day Kavli-IAU Astrochemistry Symposium at Traverse City, MI, USA in July 2023. The program was divided into 6 topics which were distributed in 9 morning/afternoon sessions, leaving an afternoon free for social purposes, with two senior members of the community providing an introductory and a summary talk. We had ample time for discussions at the end of each topic. Topic 5 (Grounding Information: Laboratory Astrophysics and Theory) was distributed within the other scientific topics, to make sure that it was followed by the various communities. Topic 6 (Future missions) was also integrated into talks across the other scientific topics. This was especially important to allow discussions and exchanges for the identification of current and future needs of the astrophysical community to be directed to our experimental and theoretical astrochemistry colleagues. Poster sessions have been organized during 2 evenings, allowing at least 2 hours per session. Each topic has been introduced by a Keynote speaker (45 min), followed by invited (30 min) and contributed talks (15 min), for a total of 3 Kavli-Keynote, 5 Keynote, and 17 invited speakers.

We have included speakers from the laboratory, observational and theoretical astrochemical community to ensure constructive exchange, as well as experts in various astrophysical fields, from the early Universe to our Galaxy to star- and planet-formation to exoplanets to our Solar System, linked by the common interest on Astrochemistry. In line with IAU guidance, in our invited speaker list we have ensured gender and geographic balance and also paid particular attention to junior scientists, who have suffered the most from the isolation during the pandemic. We wanted them to enjoy fully the fruitful live discussions with their peers and more senior scientists in this large Symposium.

We note that this was an international conference with attendees from all over the world including Thailand, India, Nepal, numerous countries in Europe, Korea, Japan, Taiwan, and of course, the United States.

IAUS 383 was an extremely successful symposium that brought together several astrophysical communities all linked by Astrochemistry: from the early Universe to star- and planet-formation and evolution in our Milky Way and local galaxies, to exoplanet atmospheres, and our Solar System. Excellent talks and posters focusing on astrophysical observations, theoretical chemistry, and laboratory experiments highlighted the interdis-

ciplinarity of Astrochemistry and the need for close collaborations among these various disciplines to unveil the chemical evolution of our Universe and our origins. Ample time for discussion made it possible for young researchers and students with different backgrounds to exchange ideas and connect with more senior people.

The conference was attended by 195 individuals. The gender balance of the attendees was impressive with 99 women and 96 men. The vast majority of the attendees were graduate students and postdoctoral fellows with informal accounting showing 65% of the attendees at this level.

The conference itself was spectacular as it has been a long time since the field was together in one place and it was a true celebration of science. Details on the Symposium can be found at the website https://events.mpe.mpg.de/event/14/, while pictures can be found at
https://michiganphotostore.photoshelter.com/galleries/C0000.T6l6oYOZow/G0000PM37rlnkrcQ/MPHOTO-Kavli-IAUsymp23.

3. Future Plans

Astrochemistry is at the heart of many astrophysical fields, from the early Universe to local galaxies, to star- and planet-formation and evolution in our Milky Way, to exoplanet atmospheres, and to our Solar System. Decades-long concerted efforts of astronomers and theoretical/experimental chemists have provided a solid base for using molecules as powerful diagnostic tools of the physical and chemical structure, dynamics, and history of a multitude of astrophysical objects, allowing connections and glimpses into the life cycle of the interstellar medium, as well as into the growth of chemical complexity in space. The great sensitivity, high angular resolution, and frequency coverage of telescopes such as ALMA have allowed unprecedented views of stellar and planet nurseries. JWST with its sensitive near- to mid-infrared spectrometers has opened a new sensitive and sharp observing window into major molecular ingredients such as water, carbon dioxide as well as other key organic species. JWST has started to probe the composition of ices on interstellar and planet-forming scales, enabling studies of the linked chemistry of exoplanetary atmospheres and protoplanetary disks.

The journey of Astrochemistry is at the beginning and a lot of work is ahead of us. For this reason, we plan to continue the activities of Commission H2 to keep advertising the crucial role of astrochemistry in astronomy, participating in summer schools and other education programs, maintaining interdisciplinary links with scientists in other fields including physical chemists, spectroscopists, and astrobiologists, and connecting the exploding field of exoplanet characterization to our field which has pioneered the astrophysical/chemical connections.

Paola Caselli
President of the Commission