

Submission of a Proposal for a Commission: Letter of Intent

Proposed Commission

Name of the Commission: Astrochemistry

Temporary Commission code: NC-22

Proposer details

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Commission Category

Regular Commission

Parent Division: Division H Interstellar Matter and Local Universe

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Rationale

Commission replaces existing Working Group: Division H Commission 34 WG Astrochemistry

Text:

Astrochemistry, or molecular astrophysics, is the study of molecules in space, one of the most rapidly growing areas of astronomy in the last two decades with applications in a wide range of astronomical environments from planetary atmospheres and comets in the Solar System to distant starburst galaxies at redshifts greater than 6. Molecules are unique probes of these many environments giving information on density, temperature, dynamics and magnetic fields. In addition, molecular compositions of various astronomical sources tell us history of matter in the Universe, and provide us with crucial information on the origin of the Solar system.

Observations of absorption and emission lines from molecules are being used currently to study interstellar gas in diffuse and dense interstellar clouds, protostellar objects, maser and star-forming regions, protoplanetary disks, the envelopes of evolved stars and planetary nebulae, and exo-planetary atmospheres. In addition to observations of our Milky Way, molecules and solid-state features are routinely detected in the interstellar medium of external galaxies ranging from our nearest neighbours, the Magellanic Clouds, to distant starburst galaxies observed at times only 10% of the age of the universe. Indeed molecules play an important role in the early universe where the cooling they provide is critical to the formation of the first stars and galaxies. Molecules are also key probes of galactic assembly processes, e.g., mergers vs. smooth accretion, and molecular gas provides the fuel for star formation and black hole activity. The role of molecules in astronomy has grown to such an extent that it is no longer an exaggeration to refer to a sizeable portion of the universe as 'The Molecular Universe'.

For chemists, the synthesis of molecules from simple atoms to more complex species is a topic of increasing interest with the distant goal of learning about pre-biotic chemistry through studies of cometary samples and meteorites as well as the protoplanetary disks that are the precursors of planets. More generally, the chemical processes at work in astronomy are of intrinsic interest because the interstellar medium provides an extreme environment that is not readily simulated on Earth. Thus, astrochemistry attracts scientists from a number of different disciplines such as chemistry and planetary science. It directly connects with new fields such as astrobiology and the study of exoplanets and their atmospheres. Because of this broad perspective, astrochemistry is a rich and vibrant field, with many adherents throughout the world and the potential for huge growth as new and more powerful telescopes search for molecules. Collaboration among scientists from several countries is now commonplace and large-scale international cooperation occurs in the construction of expensive telescopes, such as the Herschel Space Observatory and the Atacama Large Millimeter Array, for which the initial scientific cases were largely driven by astrochemists.

Astrochemistry has a Working Group in the IAU Division VI (new Division H), Commission 34 (Interstellar Matter). The WG currently consists of 12 members drawn from 10 countries and represent disciplines from laboratory astrophysics to chemical kinetic modeling to observational astronomy. We envisage that the WG may be augmented by, at most, 2-3 associate members who will cover topics in chemical physics of importance in astronomy but which is lacking amongst the WG members.

The WG aims to foster interest in the subject and ensuring that appropriate international meetings are held under the auspices of the IAU. So far, five large and successful IAU-sponsored meetings have been held, roughly every 5-6 years: IAU Symposium 120, in Goa, India 1985 on "Astrochemistry"; IAU Symposium 150 on "Astrochemistry of Cosmic Phenomena" in Brazil 1991; attended by 120 scientists from 19 countries; IAU Symposium 178, "Molecules in Astrophysics: Probes and Processes" in Leiden, The Netherlands 1996, with 231 participants from 27 countries; IAU Symposium 197 "Astrochemistry: From Molecular Clouds to Planetary Systems" in Sogwipo, Korea 1999, attended by 262 participants from 25 countries; IAU Symposium 231 "Astrochemistry: Recent Successes and Current Challenges" in Asilomar, USA in 2005 with 300 participants from 26 countries, and IAU Symposium 280 "The Molecular Universe" in Toledo in May 2011 which had 440 registered participants, limited by logistics, from 31 countries with over 500 people pre-registered. Worldwide, the number of practitioners of astrochemistry is expected to be at least double this number. The activity and growth of the field is further illustrated by a number of other international meetings and workshops around the world, including numerous meetings having to do with planning for the Herschel and ALMA telescopes, as well as dedicated networks on astrochemistry on a regional and continental basis. The purpose of the IAU symposia has been to ensure that the many aspects of astrochemistry are reviewed, and that the entire community (both astronomers and chemists/physicists) is brought together. To this end, an important development has been the creation of the Astrochemistry Sub-division of the American Chemical Society which organises sessions on the subject at each, bi-annual meetings of the ACS, thereby widening the field to a very large range of physical chemists. The WG will work closely with the officers of this sub-division to ensure the topicality of these regular meetings.

Based on the growth of the field, the sustained activity of the working group for over 20 years, and exciting future prospects, we propose to elevate Astrochemistry to a proper commission under Division H. Among the activities that can be enhanced as a full-fledged commission over the next 6-9 years are the following:

- 1 Advertising the role of astrochemistry and its multiple uses in astronomy, so that all astronomers, young and old, can develop a proper appreciation of what molecules can teach them about the sources they study; this would be done through continued IAU symposia, co-sponsoring symposia of related commissions and working groups, and expanding the web site of the commission.
- 2 Emphasizing the large amount of new molecular data coming and to come from the new generation of telescopes such as Herschel, eVLA, SOFIA, ALMA, and JWST; this would be accomplished by ensuring links to relevant data products on the IAU commission website.
- 3 Attempting to expand a knowledge of astrochemistry among all astronomers so that they can incorporate the results of the subject into their research by, for example, learning how to use molecular databases and suitable software; this would be accomplished through stimulating or co-sponsoring summer schools and through tutorials/examples/links to software on the IAU commission website – see, for example, the UMIST Database for Astrochemistry, www.udfa.net.
- 4 Maintaining interdisciplinary activities with scientists in other fields such as chemists and chemical physicists. This is accomplished by organizing symposia on astrochemistry at large chemical meetings such as those of the American Chemical Society and Royal Society of Chemistry, and sending members of the working group/commission to various conferences in the chemical community to discuss the field.

The immediate task for the Commission is to upgrade its web site, to build on the relevant focus and business meetings at the XXIX

General Assembly in Hawaii to raise awareness and interest, assuming that this request for an upgrade is granted, and to plan for the next IAU Symposium on Astrochemistry which we plan to hold in Chile in 2017.

The proposed commission would complement IAU Division H Commission 34, which is focused on the physical processes in the interstellar medium and during stellar and planetary formation, and IAU Division B Commission 14, which is dedicated to Atomic and Molecular Data but not their integration with astronomy.