

COMMISSION B5

Laboratory Astrophysics

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COMMISSION B5 WORKING GROUPS

Div. B / Commission B5 WG1 **High-Accuracy Stellar Spectroscopy**
Div. B / Commission B5 WG2 **Spectroscopic and Radiative Data for Molecules**

TRIENNIAL REPORT 2018-2021

1. Background

The Laboratory Astrophysics Commission B5 exists to address the needs of modern astronomy and planetary sciences, for results that can only be determined through theoretical and empirical means, to provide atomic and molecular data in its broadest sense, pertaining to the observational needs of the wider astronomical community. Very often these data needs are critical to the highest scientific returns from missions and observations, but often are the "poor partner" with the majority of national space agencies and funding bodies very willing to invest in the new telescopes and instrumentation for missions, but not underpin these scientific returns with the necessary vital data needs. It is therefore excellent that our community receives equal recognition from the IAU and astronomy as a whole, in the vital work we do. However as the era of "big data" evolves, this issue is being further recognised and becoming a greater challenge, and the Laboratory Astrophysics Division is proud that this need is recognised by the IAU, and therefore we continue to work to ensure laboratory data is given strong referencing, appropriate databasing and recognition for its role in modern astronomy research, whilst promoting the IAU and its mission beyond the confines of astronomy researchers.

By its nature Laboratory Astrophysics is a cross-disciplinary subject, and therefore interacts with many different IAU commissions, and tries to engage with different areas of astrophysics research. Keeping dialogue between scientists in interdisciplinary fields is important, and alongside reinforcing the synergies between laboratory astrophysics and observational astronomy and modelling, we continue to work within the commission to harmonise nuclear, atomic molecular and materials scientists working cooperatively with different laboratory astrophysics experiments. On the one hand, our commission clearly bring new "blood" to the IAU, introducing non-IAU members to IAU events; on the other we face the challenge that many working in our field are members of professional bodies that are not the national nominating bodies for the IAU, and therefore not IAU members - nevertheless, we work hard to cooperate and work with IAU efforts and activities.

2. Developments within the past triennial

2.1. *Commission Membership*

On a positive note the Commission B5 has seen a ~ 10 % rise in membership over the last triennial, with a number of enquiries from junior IAU members, which is exciting, as it shows the health of the field and the interest in laboratory astrophysics growing. Our membership has also diversified beyond the "usual" laboratory astrophysics power-house laboratories in the USA Europe and Japan, to encompass members in South America, Africa, Far East, India, Russia and Australia. It is very positive to see the reach of experimental physics and chemistry as applied to astronomy reaching world-wide. Our IAU members include astronomers, astrophysicists, astrochemists, astrobiologists and geologists, although many major players in the field at large are not yet involved with the IAU (beyond attending symposia) as their national professional affiliations precluded them from being nominated as members. Going forwards to the next triennial this is something this commission would like to work on.

Commission B5 currently has 153 members, and supports two working groups, both focused on data needs of different astronomical communities, but where the IAU kudos is important to the nature and integrity of the data produced and astronomical data use. Again going forwards to the next triennial, members of the OC would very much like to work further with the IAU and other international organisations on how best to build and very laboratory astrophysics data banks in a way that benefits the whole astronomical community and also the laboratory astrophysicists whose work must continue to be cited.

2.2. *Communication*

Communication to commission members continues to come via president-led emails, although the commission is always open to input from all its members and encourages members of the commission to bring ideas forwards. There are always at least 2-3 communications and updates per annum, and we trust this strikes the balance between communication and not overloading already busy inboxes. The commission actively solicits its membership to nominate individuals for the IAU prizes, and has been proud that in both 2019 and 2021 the IAU Division PhD Prize was won by individuals with research in Laboratory Astrophysics. Likewise during IAU symposia, GAs and election periods and voting we actively encourage members to engage by submitting abstracts, nominating themselves or others and voting - in 2021 we have 3 individual standing for 1 vice-president position and 7 individuals standing, from a variety of nationalities world-wide for OC membership. Not only is our commission enthusiastic but the members are willing to step up volunteer and engage in IAU operations very positively. One aim of the past triennial has been to build links with other Divisions and commissions - this has been achieved in part through links with Division E, F, G and H, although since laboratory astrophysics underpins much of modern astronomical observations we would like to extend this in the next triennial.

2.3. *Working Groups*

There are two current working groups in Commission B5:

The Working Group on Spectroscopic and Radiative Data for Molecules within Commission B5 compiled relevant publications appearing since the IAU General Assembly in 2018 so that the astronomical community is made aware of the recent work in this area for their research needs. The information provided by the Working Group is used in studies of stellar atmospheres, exoplanets, planetary objects in the Solar System, and interstellar clouds in the Galaxy and beyond. The current compilation will be presented

in the Triennial Report of the Working Group for the upcoming General Assembly along with links to databases containing these data. Experimental and theoretical data for rotational, vibrational, and electronic transitions are presented in separate sections of the Report. In particular, new results on wavelengths and frequencies for transitions, transition probabilities (and related oscillator strengths), and cross sections and rates for processes involving photons (photoionization and photodissociation) are collected. The members of the Working Group plan to continue these efforts in the next triennial as a vital service to the astronomical community supported by Comm B5. A separate full triennial report of the working group is provided to the IAU.

The Working Group on High-Accuracy Stellar Spectroscopy within Commission B5 promotes work on the high-accuracy atomic and molecular data required for accurate stellar spectroscopy, especially through encouraging the interplay between theoretical atomic physics, laboratory spectroscopy, and astrophysical observations. Several conferences and workshops have promoted these themes with WG members being involved in input into 6 meetings outside the IAU promoting these activities. In addition the group had a major feed-in to two white papers produced for the Astro2020 AAS decadal review:

Nave, G., and 30 colleagues 2019. Atomic data for astrophysics: Needs and challenges. *Bulletin of the American Astronomical Society* 51, 1. Savin, D.W., and 64 colleagues 2019. State of the Profession Considerations for Laboratory Astrophysics. *Bulletin of the American Astronomical Society* 51, 7.

which amongst other areas promote the excellent collaborative work ongoing in theoretical and experimental studies of NeII which is important for resolving the discrepancy between the current solar abundances derived from spectroscopic observations, and those abundances required in opacities for solar structure models to reproduce helioseismic observations.

Again Comm B5 has recommended this working group continues its work in the next triennial.

2.4. *Meetings and Symposia*

The Commission has supported two nominations from IAU symposia since 2018 (both submitted in 2019), since which world events have precluded further symposia calls. As president HJF will form part of the SOC for the IAU GA Symposium accepted for presentation at the IAU GA in Busan in August 2021 (now 2022) Honoring Charlotte Moore Sitterly: Astronomical spectroscopy in the 21st century." led by David Soderblom President of Division G, and we look at this as a real opportunity to work with another division in the IAU, and particularly to coordinate efforts with the Stellar community. As a result of this very direct support we did not propose a FM for the IAU GA, but hope to continue our efforts in this regard for 2024, looking particularly at links with the exoplanet and astrobiology communities - initial activities towards this started in 2019, and will continue after the next GA and in readiness for the next IAU call.

2.5. *IAU S350 - Symposia: Laboratory Astrophysics: From Observations to Interpretation*

The highlight of the Commission's work in the past triennial is our first ever commission-led IAU Symposium. Held from April 14 - 19th 2019 at Jesus College, Cambridge, UK, the symposium attracted 167 laboratory astrophysicists from around the world, including 27 different nationalities and with approximately 4/10 of the participants being female, and over half begin early career researchers, the meeting showed great diversity. Over 40 travel grants were given to support attendees, supported by national agencies as well as the IAU and Europlanet. In late 2020 the proceedings were made available electronically

and in printed format for the benefit of attendees and the wide variety of sponsors who supported the event. The symposium was used to produce a video of all female attendees stating "We are laboratory astrophysicists" for inclusion in the IAU diversity video made for the centenary celebrations. In keeping with the IAU mission of astronomy for diversity, development and diplomacy, public events were an integral part of the meeting, including two public lectures that were also broadcast via YouTube and available worldwide to IAU audiences to watch at the time and afterwards, as well as a public outreach afternoon where the conference lecture theatre and environs was converted into a haven for schools and families with children "craft building" lab astrophysics experiments, learning about interstellar and cometary ices, walking through 3-D virtual ice molecular structures, using spectroscopy, and experiencing planetary science by testing geological surfaces and formations. In all the IAU S350 public programs reached over 4000 individuals worldwide.

Scientifically the meeting included over 100 posters and 40 talks, including review, invited and contributed talks, enabling individuals at all career stages to present their work. Significant time was allocated to networking with on-site catering and all the posters available all the week to discuss, as well as on-site (and off-site) accommodation. Additional industrial and publisher sponsorship enabled some social events and trips to punt on Cam, visit the Mullard radio observatory and Ely cathedral. The scientific content was exceedingly broad ranging from atomic and nuclear physics, to dust and astrobiology as well as geology of meteorites as well as more "traditional" ice molecular surface chemistry and high resolution gas-phase spectroscopy. We were honoured that Prof Ewine van Dishoeck attended (both in a scientific capacity and as IAU president) and thank enormously the scientific and local organising committees for their outstanding work. In particular the SOC embodied our geographic and scientific diversity and forged links with other commissions; Farid Salama (Chair) NASA/ARC, USA, Paul Barklem Uppsala University, Sweden, Helen Fraser Open University, UK, Thomas Henning MPI Heidelberg, Germany, Christine Joblin University of Toulouse, France, Sun Kwok University of Hongkong, China (representing Division F), Harold Linnartz Leiden University, Netherlands, Lyudmila Mashonkina RAS, Russian Federation, Tom Millar Queens Univ. Belfast, UK (representing Division H), Osama Shalabiea Cairo University, Egypt, Gianfranco Vidali Syracuse University, USA, Feilu Wang NAO, China, Giulio Del-Zanna University of Cambridge, UK (representing Division E).

2.6. *The Impact of Covid*

It is impossible to complete a report on the last triennial without mentioning Covid and its impact in curtailing IAU activities in general and those of the commission in particular. Where usually IAU symposia would have continued to be supported, this year those activities have been limited or non-existent. However beyond the "usual" IAU activities, the impact of Covid has been very stark on the laboratory astrophysics community. Major facilities and laboratories have been shut down world-wide and in many instances remain closed. Most countries have shut their large-scale laboratory facilities and "work from home" requirements, coupled with home-schooling, curfews and non-access to laboratories has brought much laboratory astrophysics work to a halt. Even in places and countries where some lab return has been possible, social distancing and limited technical support strongly limit work and pace of research being undertaken. In a field where productivity differs greatly in terms of publications per individual than in astronomy as a whole, the commission has a key role to play in helping to educate others and support our community as the post-pandemic world restarts, particularly for careers of younger members.

In a process where the complexities of the situation are not lost, the OC recognised early in 2020 that the laboratory astrophysics community was adversely affected in these

times. We looked at the potential to organise monthly "unpublished data seminars" to encourage all the community to look at how inventive we could be in continuing to develop the field when access to new data was so limited and archives not public. However the additional academic teaching loads and home life demands on many commission members worldwide, coupled with "zoom exhaustion" from so many similar initiatives (all be it in broader astronomy seminars) simply precluded this opportunity this past 12 months. Going forwards however it seems many junior IAU members may exactly have the time and willingness to undertake such endeavours and we look forward to making such opportunities through 2021/22. As the post-pandemic world resumes, laboratory astrophysics will certainly require a strong boost and the natural place will therefore be to continue the IAU Symposia series we have started, by looking to 2023 and the next IAU Symposium in Laboratory Astrophysics.

3. Summary

In conclusion this last triennial has built strongly on the hard work of the first triennial of Commission B5 (led by Farid Salama) and the predecessor of this Commission, Comm 14 in Atomic and Molecular Data. Looking back on our last triennial report we have successfully grown the group membership and engagement, linked to new divisions within the IAU and delivered a scientifically excellent IAU Symposium. The challenges of the next triennial will be mixed with the new ways of working communicating and disseminating science under ongoing Covid-restrictions, as well as the promise of many new telescopes and missions, demanding ever more data and underpinning laboratory science to ensure the greatest scientific returns and understanding - laboratory astrophysics has a bright future, and with it, real opportunities to continue to collaborate, diversify and engage with the IAU.

Helen Fraser
President of the Commission