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Editorial: Frontiers in astronomy and space sciences: Rising stars

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Editorial on the Research Topic
Frontiers in astronomy and space sciences: Rising stars

We are delighted to present the inaugural Frontiers in Astronomy and Space Sciences "Rising Stars" article collection. This collection showcases the high-quality work of internationally recognized researchers in the early stages of their independent careers.

All Rising Star researchers were individually nominated by the editors of the Journal in recognition of their potential to influence future directions in their respective fields. The work presented here highlights the diversity of research across the breadth of astronomy and space sciences and presents advances in theory, experiment, and methodology, providing applications for compelling problems. New articles will be added to this collection as they are published. Contributions to "Rising Stars" are by invitation only.

The first "Rising Stars" article collection consists of five manuscripts. Two are extragalactic and discuss narrow-line Seyfert 1 galaxies and the AGN radius-luminosity relation, one paper reports on the lack of detected exoplanet transits for Proxima Centauri, and finally, two papers cover topics on gas-phase reactivity in the Interstellar Medium and PO^+ detection in the G+.693–0.027 molecular cloud.

Extragalactic astronomy

It was soon realized after the discovery of quasars that there is a radio-quiet majority behind "quasi stellar radio sources", optical counterparts of the then-mysterious sources dominating the sky in the radio wavebands. Since then the relation between the two classes—radio quiet and radio loud active galactic nuclei (AGN)—has remained an open issue. The latest developments have ushered the sensitivity of radio instrumentation in the domain of the μ Jansky, and they have considerably complicated the matter, revealing sources that are endowed with a relativistic jet but that are also very faint, implying the possibility of contamination by circumnuclear or host Galaxy radio emission, which is ultimately associated with star formation. Of special interest in this context are the so-called radio-loud Narrow Line Seyfert 1s (RL NLSy1s) analyzed by Järvelä et al., whose radio-quiet counterpart is a class of AGN that drives the correlations of the famed Eigenvector 1 parameter space and that has been accounted for as a young or rejuvenated form of nuclear activity (Sulentic et al., 2000). As Järvelä et al. say, NLSy1s are complicated sources, where often an interplay between the AGN, the various phenomena related to it, and the host Galaxy can be seen. As such they, however, offer us an unprecedented view of the early stages of the evolution of powerful AGN. RL NLSy1s are rare and low radio power sources; yet, their properties suggest the presence of a relativistic radio jet, even if it is associated with a modest black hole mass ($M_{\rm BH} \sim 10^6 M_{\odot}$). Järvelä et al. present a study of several RL NLSy1s and attempt to unveil their complexity by computing radio spectral index maps. According to these authors, each source is a case in its own right, but they generally fit the scenario of a fledgling nuclear activity. A more thorough view might eventually emerge from radio observations covering a wide range of radio frequencies (from 100 MHz to 50 GHz) made possible by present-day low-frequency arrays and by new generation high-frequency receivers.

The paper by Panda presents a comprehensive analysis of the issues associated with the scaling laws between the radius of the broad line emitting region $r_{\rm BLR}$ of type-1 AGN (Seyfert 1 and quasars) and the luminosity. Following extensive reverberation mapping campaigns, it has become clear that type-1 AGN do not follow a universal scaling law in the simplest form $r_{BLR} \propto L^{0.5}$, as originally suggested. The original formulation of this law remains valid for only a fraction of type-1 AGN, the ones accreting at modest rates (Population B; Sulentic et al., 2000). Highly accreting sources (Population and extreme Population A; Marziani and Sulentic 2014) present a significant deviation in the sense that the emitting regions are closer to continuum sources: the higher the dimensionless accretion rate (or the Eddington ratio), the closer the emitting region is found. The important result of the Panda analysis is a relation between radius and luminosity with a dependence on the Eddington ratio (or an observational proxy) and physical conditions, expressed by the product of ionization parameter and number density (his Eqs 7–10). Photoionization computations and an application of the dust sublimation prescription permit the recovery of information on the physical conditions for the emitting regions of the two prototypical sources I Zw 1 (Pop. A) and NGC 5548 (Pop. B) that reproduces their observed emission line equivalent widths and some line intensity ratios. As discussed by the author, this is just one step toward a complete, self-consistent model of the broad line emitting regions, a daunting task given their complexity.

Exoplanets

In a well-honed experiment, Gilbert et al. use high-quality TESS photometric observations of Proxima Centauri to search for planet transits. Proxima Cen is known to have a 1.3 earth-mass planet in an 11 days orbit (Anglada-Escudé et al., 2016) and possibly at least one additional planet with a longer period (Damasso et al., 2020). The short orbital period planet, in its close orbit (0.05 AU), places it within the habitable zone of this M star. A number of previous studies (e.g., Kipping et al., 2017; Li et al., 2017) have searched for transits of this short-period planet without success. However, the high-value of planetary atmospheric observations by JWST, for example, provided a strong motivation for the team to redo a detailed search for planetary transits.

Proxima Cen is an active M5.5 star with frequent flares making the light curve highly resistant to finding small planet transits (Thackeray, 1950; MacGregor et al., 2021). Therefore, the authors developed and used some novel software methods to examine in detail the light curve of Proxima Cen in search of transits. While no planet transits were detected for Proxima Cen, this study set stringent limits on transiting planets, particularly those within the habitable zone.

Astrochemistry

In Alessandrini and Melosso, the gas-phase reaction between oxirane (c-C_2H_4O) and the CN radical has been computationally investigated, both considering thermochemistry and kinetics. Such a reaction was thought to offer a feasible pathway to the formation of species with C_3H_3NO molecular formula, which is a family of compounds rather elusive in the interstellar medium. Thermochemistry, studied by means of a double-hybrid density functional, revealed several submerged mechanisms with respect to the reactants energy, with the potential formation of oxazole and cyanoacetaldehyde. However, kinetics suggest that the main reaction mechanism is the extraction of an H atom, thus leading to the 2-oxiranyl radical and hydrogen cyanide (HCN), with cyanoacetaldehyde + H and H_2CCN + H_2CO being also possible reaction products characterized by lower rate constants. The production of oxazole is instead negligible due to the presence of a high energy barrier. In conclusion, in the gas-phase reaction between oxirane and the CN radical, the only species belonging to the C_3H_3NO family whose formation is thermochemical and kinetic feasible is cyanoacetaldehyde. This study also pointed out that, differently from what is reported in the literature for many cyano-containing molecules, the c-C_2H_4O + CN reaction does not form the cyano-derivative of the reaction partner (i.e., cyanooxirane), because the nucleophilic attack of the CN radical always leads to ring opening. This result might explain why, despite the detection of oxirane and the abundance of CN, astronomical searches for cyanooxirane have been so far unsuccessful.

Rivilla et al. reported the first detection of the phosphorus monoxide ion (PO^+) in the interstellar medium. Four different rotational transitions of this molecule, with two of them free from contamination by other species, were found in an unbiased and very sensitive spectral survey toward the G+0.693–0.027 molecular cloud. Assuming local thermodynamic equilibrium conditions, the analysis of these lines yielded a column density N of $(6.0 \pm 0.7) \times 10^{11}$ cm^2, which means a molecular abundance with respect to molecular hydrogen of $4.5 \times 10^{--12}$. Interestingly, the authors found that the column density of PO^+ normalized with respect to the cosmic abundance of elemental phosphorous is greater than those of NO^+ and SO^+ normalized with respect to N and S elemental abundance by factors of 3.6 and 2.3, respectively. The $N(PO^+)/N(PO)$ ratio was found to be 0.12 ± 0.03, which is more than one order of magnitude larger than that of $N(SO^+)/N(SO)$ and $N(NO^+)/N(NO)$, thus indicating that–in the ISM–P is more efficiently ionized than N and S. These results have been explained by the fact that in shocked regions with high values of cosmic-ray ionization rates such as the G+0.693–0.027 molecular cloud, atomic P is easily formed and then ionized efficiently by cosmic rays, thus leading to P^+, which produces PO^+ by reacting O_2 and/or OH. The cosmic-ray ionization of PO might also contribute significantly, thus explaining the $N(PO^+)/N(PO)$ ratio observed.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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