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EDITORIAL
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Editorial: Horizons in Astronomy and Astrophysics

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Editorial on the Research Topic

Horizons in Astronomy and Astrophysics

We are delighted to present the inaugural "Horizons in Astronomy and Astrophysics" article collection. This collection showcases high-impact, authoritative and reader-friendly review articles covering important topics at the forefront of Astronomy and Astrophysics.

The contributing authors were nominated by the Chief Editors of the Journal in recognition of their prominence and influence in their respective fields. The cutting-edge work presented in this article collection highlights the diversity of research performed across the entire breadth of Astronomy and Astrophysics, and reflects on the latest advances in the theory, experiment and methodology with applications to compelling problems.

The contribution of Luigi Foschini "Some Notes About the Current Researches on the Physics of Relativistic Jets" (Foschini) provides an effective critical review about one of the most long-standing mysteries in extra-galactic astrophysics: the origin of relativistic radio ejections from the nuclei of galaxies. There are still fundamental issues lingering since the early days of radio astronomy, even after the many stunning images produced by the very large array and to long base-interferometry in the most advanced expressions (such as space-based interferometry and the Event Horizon Telescope). Several basic issues are tackled: among them, the interpretation of the fundamental scaling laws of black hole accretion, actually defined on biased sample and unfit to express a fundamental accretion disk connection; the breaking-down of the blazar sequence jet power vs. electron cooling; the intermittent nature of the jet; the possibility of lepto-hadronic models to explain the jet acceleration and some multimessenger phenomena associated with blazars; the jet energy dissipation, and others. The paper poses many challenging questions that are still actual and that are reminescent of the ones posed to eminent workers 10 years ago (Marziani et al., 2012). The horizon has been broadened but perhaps not as much as we had wished for.

The contribution of Barone and Puzzarini "Toward accurate formation routes of complex organic molecules in the interstellar medium: the paradigmatic cases of acrylonitrile and cyanomethanimine" (Barone and Puzzarini) highlights new information about important reactive channels operative in different regions of the interstellar medium (ISM) and in the atmospheres of exoplanets. The ISM is characterized by extreme physical conditions: temperatures that are usually very low (10–200 K), densities that are so low that can be considered as a high vacuum on Earth, and ionizing radiation such as cosmic and UV rays (Yamamoto, 2017). Despite such a harsh environment, its chemistry is very rich. Owing to radioastronomy, about 270 molecules have been detected so far (Endres et al., 2016), with more than one third of them belonging to the so-called "complex organic molecules" [i.e., molecules with more than 5 atoms and containing at least 1 C atom; Herbst and van Dishoeck (2009)]. As addressed in the contribution Barone and Puzzarini, chemical reactions in the ISM can occur on the surface of interstellar dust grains or in the gas phase. In both cases, reactivity has severe

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constraints: the reaction should be exothermic, should start with a barrierless approach of the reactants and must proceed with mechanisms only involving submerged reaction barriers. As a consequence, one of the reactants should be a very reactive species like radicals and ions. This behavior is explained by the fact that reactants can only count on their own energy, they do not get any "help" from the environment. In Barone and Puzzarini, focusing on reactions taking place in the gas phase, it is demonstrated that quantum-chemical calculations at the state of the art are able to derive reactions mechanisms able to explain the reactivity of the ISM. Accurate computations of the thermochemistry and kinetics provide useful information for the rationalization of chemistry of the ISM.

The contribution of Antolin and Froment "Multi-scale variability of coronal loops set by thermal non-equilibrium and instability as a probe for coronal heating" (Antolin and Froment) explores properties of solar coronal loops as fundamental building blocks of the Sun's enigmatically hot corona. These dynamic coronal structures are shaped by the magnetic field that expands into the solar atmosphere where they can be observed in extreme ultraviolet (EUV) and X-ray wavelengths—indicating the million plus Kelvin temperature of the emitting plasma. While the dissipation of magnetic energy to heat the plasma to millions of degrees is the likely culprit, the mechanisms setting the mass and energy circulation in the solar atmosphere is still a matter of debate and raised by the authors. They discuss that multi-dimensional numerical models indicate that the very concept of a coronal loop as an individual entity is ill-defined due to the expected stochasticity of the solar atmosphere driven by magneto-convection. Highlighting the recent discovery of ubiquitous long-period EUV pulsations, the observed coronal rain properties and their common link in between represent not only major observational constraints for coronal heating theories but also major theoretical puzzles. The mechanisms of thermal non-equilibrium (TNE) and thermal instability (TI) appear in concert to explain these multi-scale phenomena as evaporation-condensation cycles. Recent numerical efforts clearly illustrate the specific but large parameter space involved in the heating and cooling aspects, and the geometry of the loop affecting the onset and properties of such cycles. Their review presents and discusses this new approach to inferring coronal heating properties and understanding the mass and energy cycle based on the multi-scale intensity variability and cooling properties set by the TNE-TI scenario.

The contribution of Tennyson and Yurchenko "High accuracy molecular line lists for studies of exoplanets and other hot atmospheres" (Tennyson and Yurchenko) explores the desire to characterize the atmospheres of extrasolar planets that have been discovered over the last 3 decades. This goal is limited by the lack of spectroscopic data on the atmospheric molecules other species that are readily available from laboratory studies. The authors review the currently available molecule spectra for studies of exoplanet atmospheres, and the atmospheres of astronomical objects hotter than the Earth such as brown dwarfs, cool stars and even sunspots. They discuss the dependency of exoplanet transit spectra and opacities analysis which often require huge datasets comprising billions of individual spectroscopic transitions, while the new high resolution Doppler spectroscopy techniques rely on the use of smaller, but very accurate line lists. They conclude their contribution with a discussion on resolving the competing demands of completeness versus accuracy for line lists needed top explore and advance the Frontier field.

The contribution of Herbst and Garrod "Synthetic approaches to complex organic molecules (COMs) in the cold interstellar medium" (Herbst and Garrod) highlights the observation and synthesis of organic molecules in interstellar space—one of the most exciting and rapidly growing topics in astrochemistry. They focus on the diverse suggestions made to explain the formation of COMs in the low-temperature ISM where the dominant mechanisms at such low temperatures are still a matter of dispute—where both gas-phase and granular processes are occurring on and in ice mantles. They discuss the diffusive and nondiffusive Granular mechanisms where a granular explanation is strengthened by experiments at 10 K that indicate that the synthesis of large molecules on granular ice mantles under space-like conditions is exceedingly efficient. Similarly, the bombardment of carbon-containing ice mantles in the laboratory by cosmic rays can lead to organic species even at low temperatures. Further, for processes on dust grains to be competitive at low temperatures non-thermal desorption mechanisms must be invoked to explain why the organic molecules are detected in the gas phase. Herbst and Garrod highlight that while much remains to be learned, a better understanding of low-temperature organic syntheses in space will add both to understanding of unusual chemical processes and the role of molecules in stellar evolution.

These articles provide a sample of the excellent Frontier research activities across solar, stellar and the broader astrophysics discipline. In a year of community exercises to set strategic priorities, the concepts emerging in this series will factor into those conversations. We hope that you enjoy the collection.

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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