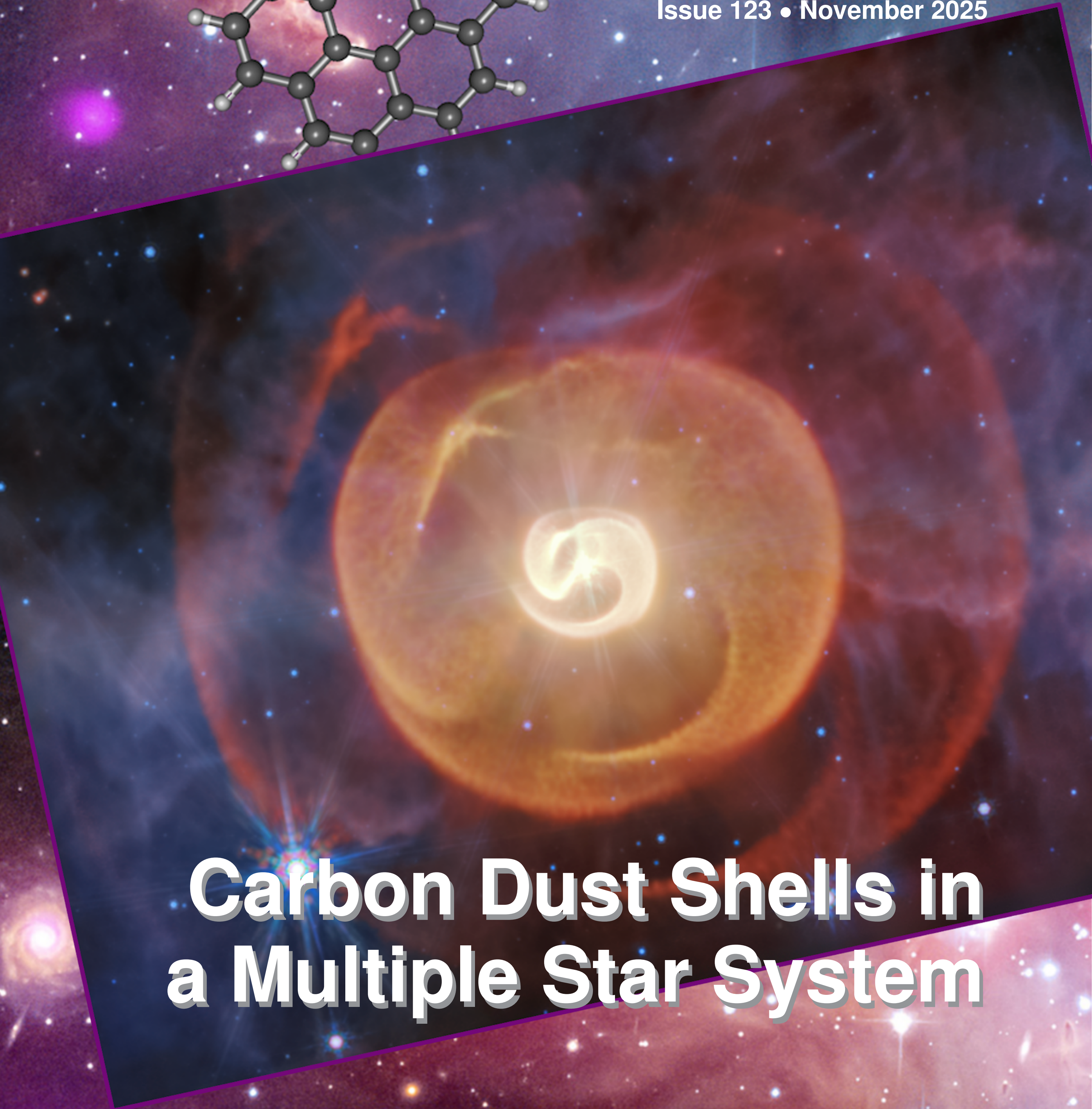
AstroPAH
A Newsletter on Astronomical PAHs

Issue 123 • November 2025



Carbon Dust Shells in a Multiple Star System

Editorial

Dear Colleagues,

Welcome to the 123rd issue of AstroPAH!

This month's cover showcases the fantastic JWST image of the spiraling shells rich in amorphous carbon dust ejected by the Wolf-Rayet binary stars in the Apep multiple star system (Han et. al. 2025).

The abstracts collected in this new issue of AstroPAH are representative of the multidisplinary character of our research and cover a broad range of PAH-related research: from observational studies revealing the presence of fullerenes in circumstellar environments with Spitzer, searching for corannulene with ALMA, and characterizing cool galactic outflow candidates with ALMA; to experiments investigating CO ice chemistry, and measuring the electronic spectra of fullerene analogs; to theoretical computations of PAH cation anharmonic infrared spectra.

AstroPAH can help you promote your research. Send your contributions to our email.

Thank you all for your contributions!

The Editorial Team

Next issue: 18 December 2025.
Submission deadline: 05 December 2025.

Contact us:

astropah@strw.leidenuniv.nl

http://astropah-news.strw.leidenuniv.nl

Click here to Subscribe to AstroPAH

Click here to Contribute to AstroPAH

Follow us on:

Contents

PAH Picture of the Month

NASA *JWST* image of spiraling shells rich in amorphous carbon dust ejected by the Wolf-Rayet stars in the Apep multiple star system (Han et. al. 2025).

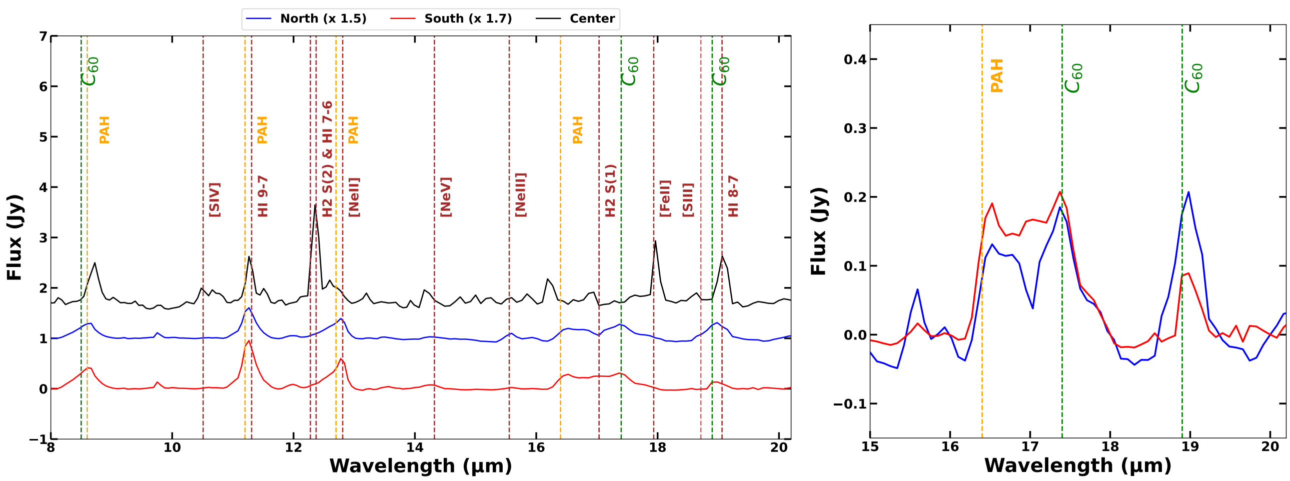
Credits: *JWST* image: NASA, ESA, CSA, STScI. Image processing: A. Pagan (STScI), from proposal 5842 (PI: Y. Han). The image is available here.

This newsletter is edited in LaTeX. Newsletter Design by: Isabel Aleman. Image Credits: Background image in this page: NASA, ESA, and the Hubble Heritage Team (STScI/AURA). Headers background: X-ray and optical image composition. X-ray by Chandra: NASA/CXC/Univ.Potsdam/L.Oskinova et al; Optical by Hubble: NASA/STScI; Infrared by Spitzer: NASA/JPL-Caltech.

Discovery of Fullerenes in the shell of candidate Luminous Blue Variable WRAY 16-232

R. Arun[1], **S. A. Prasoon**[1,2], **Blesson Mathew**[2], **D. Akhila**[3], **Gourav Banerjee**[1], **Baskaran Shridharan**[4], **Maheswar Gopinathan**[1], **Arun Surya**[1]

[1]Indian Institute of Astrophysics, Sarjapur Road, Koramangala, Bangalore, India
[2] Center of Excellence in Astronomy and Astrophysics, Department of Physics and Electronics, CHRIST (Deemed to be University), Bangalore, India
[3]Instituto de Astronomía y Ciencias Planetarias, Universidad de Atacama, Copiapó, Chile
[4]Tata Institute of Fundamental Research, Mumbai, India



Continuum-subtracted Spitzer/IRS spectra of the center, north, and south regions of WRAY 16-232 (left), offset vertically for clarity. Vertical dashed lines mark prominent emission lines and PAH/fullerene features. The zoomed-in region shows the 17.4 and 18.9 μm C_{60} features identified in the northern and southern parts of the envelope (right).

We report the discovery of fullerene in the circumstellar environment of WRAY 16-232, a strong candidate luminous blue variable. Multiple pointings of archival *Spitzer* IRS spectra reveal, for the first time, the presence of prominent vibrational bands of C_{60} at 17.4 and 18.9 μm in an LBV envelope, along with the strong polycyclic aromatic hydrocarbon features. These observations suggest that, despite the harsh radiative conditions, large carbonaceous molecules can form, process and survive in the ejecta of massive stars. Complementary optical spectroscopy with SALT HRS shows multiple P Cygni profiles in Hα, He I, and Fe II lines, which are indicative of a dense, expanding wind and substantial mass loss. Furthermore, analysis of decade long photometric data shows short-term brightness variations of $\sim$0.5 mag. These results not only reinforce the classification of WRAY 16-232 as a strong LBV candidate but also provide new insights into the mechanisms of dust formation and the chemical enrichment of the interstellar medium by massive stars.

We discuss various scenarios for fullerene formation in such environments, and find that shock processing due to wind-wind interactions could be playing a vital role. The shell of WRAY 16-232 has an ideal UV field strength and the time scales appears to match with shock processing timescales. The results highlight the need for further high spatial/spectral resolution and temporal observations to confirm the formation and survival scenario of C_{60} in its shell.

E-mail: arunroyon@gmail.com

Monthly Notices of the Royal Astronomical Society **543**, 3214 (2025)

https://doi.org/10.1093/mnras/staf1676

Irradiation of condensed CO reveals a new pathway for the formation of aromatic molecule in the astrochemical ices

Wafikul Khan[1,2], R Ramachandran[1,4], S Gupta[1], J K Meka[1], V Venkataraman[3], B N Rajasekhar[4], P Janardhan[1], Anil Bhardwaj[1], N J Mason[5], B Sivaraman[1]

[1]Physical Research Laboratory, Ahmedabad, India
[2]Indian Institute of Technology (IIT) Gandhinagar, India
[3]Space Physics Laboratory, Vikram Sarabhai Space Center, Thiruvananthapuram, India
[4]Institute of Astronomy, Space and Earth Science, Kolkata, India
[5]University of Kent, Canterbury, UK

Given the importance of carbon monoxide in the interstellar medium (ISM) both in the gas and ice phase, the condensed CO has been studied by irradiation by energetic particles and the products formed from CO dissociation have been investigated for nearly four decades. However, our understanding on the physical nature of the residue made from CO ice irradiation is limited to-date. Hence we irradiated CO ice with 2 keV electrons and probed the ice in the vacuum ultraviolet / ultraviolet (VUV/UV) spectroscopy techniques. The in-situ VUV/UV spectral analysis of irradiated product provided compelling evidence (peak at 240 nm) for the presence of a refractory residue made of carbon atoms. The ex-situ analysis carried out using high resolution transmission electron microscopy (HR-TEM) revealed the presence of ordered carbon atoms viz-a-viz graphene, graphitic carbon and quantum dots. The direct ring closure from carbon atoms released from CO reveal a new pathway to be considered in the bottom-up formation of polycyclic aromatic hydrocarbon (PAH) molecules, on cold dust in the ISM, via the hydrogenation of graphene / graphitic carbon.

E-mail: wafikulkhan36@gmail.com

Life Sciences in Space Research (2025) (Special issue ”Astrochemistry”)

https://doi.org/10.1016/j.lssr.2025.09.007

Formation of Unsaturated Carbon Chains through Carbon Chemisorption on Solid CO

Masashi Tsuge[1], Germán Molpeceres[2], Ryota Ichimura[3], Kenji Furuya[4], Hideko Nomura[3], Naoki Watanabe[1]

[1]Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan
[2]Departamento de Astrofísica Molecular, Instituto de Física Fundamental (IFF-CSIC), Madrid, Spain
[3]Division of Science, National Astronomical Observatory of Japan, Mitaka, Japan
[4]RIKEN Pioneering Research Institute, Wako, Japan

The interaction of carbon atoms with solid carbon monoxide (CO) is a fundamental process in astrochemistry, influencing the formation of complex organic molecules in interstellar environments. This study investigates the adsorption and reaction mechanisms of carbon atoms on solid CO under cryogenic conditions, employing a combination of experimental techniques, including the combination of photostimulated desorption and resonance-enhanced multiphoton ionization and infrared spectroscopy, alongside quantum chemical calculations. The results reveal the formation of oxygenated carbon chains, such as CCO, C_3O_2, and C_5O_2, as well as CO_2. The findings highlight the role of chemisorption and subsequent reactions in driving molecular complexity on solid CO, with implications for the chemical evolution of interstellar ices and the potential formation of prebiotic molecules.

E-mail: tsuge@lowtem.hokudai.ac.jp

The Astrophysical Journal **993**, 177 (2025)

https://iopscience.iop.org/article/10.3847/1538-4357/ae0a50

Anharmonic infrared spectra of cationic pyrene and superhydrogenated derivatives

Zeyuan Tang[1,2], **Frederik G. Doktor**[2], **Rijutha Jaganathan**[2], **Julianna Palotás**[3,4], **Jos Oomens**[3], **Liv Hornekær**[2,5], **Bjørk Hammer**[2]

[1]School of Chemistry and Chemical Engineering, Hainan University, China
[2]Center for Interstellar Catalysis (InterCat), Department of Physics and Astronomy, Aarhus University, Aarhus, Denmark
[3]Radboud University, Institute for Molecules and Materials, FELIX Laboratory, Nijmegen, The Netherlands
[4]School of Chemistry, University of Edinburgh, Joseph Black Building, Kings Buildings, Edinburgh, UK
[5]Interdisciplinary Nanoscience Center (iNANO), Aarhus University, Aarhus, Denmark

Studying the anharmonicity in the infrared (IR) spectra of polycyclic aromatic hydrocarbons (PAHs) at elevated temperatures is important to understand the vibrational features and chemical properties of interstellar dust, especially in the James Webb Space Telescope (JWST) era. We take pyrene as an example PAH and investigate how different degrees of superhydrogenation affect the applicability of the harmonic approximation and the role of temperature in the IR spectra of PAHs. This is achieved by comparing the theoretical IR spectra generated by classical molecular dynamics (MD) simulations and the experimental IR spectra obtained via gas-phase action spectroscopy, which utilizes the infrared multiple photon dissociation. All simulations are accelerated by a machine learning interatomic potential, in order to reach firstprinciples accuracies while keeping computational costs low. We have found that the harmonic approximation with empirical scaling factors is able to reproduce experimental band profile of pristine and partially superhydrogenated pyrene cations. However, a MD-based anharmonic treatment is mandatory in the case of fully superhydrogenated pyrene cation for matching theory and experiment. In addition, band shifts and broadenings as the temperature increases are investigated in detail. These findings may aid in the interpretation of JWST observations on the variations in band positions and widths of interstellar dust.

E-mail: zytang@hainanu.edu.cn

Journal of Chemical Physics **163**, 044304 (2025)

https://doi.org/10.1063/5.0276133
https://arxiv.org/abs/2504.11898

Searching for Corannulene with ALMA: Observations of the Red Rectangle Nebula

Elise Koo[1], Alessandra Candian[1], Michiel Hogerheijde[1,2], Lizette Guzman-Ramirez[3], Javier Alcolea[4], Valentin Bujarrabal[4], Jan Cami[5,6,7], Pierre Cox[8], Peter Sarre[9]

[1]University of Amsterdam, Anton Pannekoek Institute, Amsterdam, The Netherlands
[2]Leiden Observatory, Leiden University, Leiden, The Netherlands
[3]Eindhoven University of Technology, Eindhoven, The Netherlands
[4]Observatorio Astronomico Nacional (OAN-IGN), Alcala de Henares, Spain
[5]Department of Physics & Astronomy, The University of Western Ontario, London, ON, Canada
[6]Institute for Earth and Space Exploration, The University of Western Ontario, London, ON, Canada
[7]Carl Sagan Center, SETI Institute, Mountain View, CA, USA
[8]CNRS and Sorbonne Universite, UMR 7095, Institut d'Astrophysique de Paris, Paris, France
[9]School of Chemistry, The University of Nottingham, Nottingham, UK

Polycyclic Aromatic Hydrocarbons (PAHs) are organic molecules responsible for the Aromatic Infrared Bands (AIBs), observed across a multitude of astrophysical environments. Despite their ubiquity, the precise formation mechanisms of PAHs remain unclear. One of the possible way for PAHs to form is in the outflows of evolved stars, such as HD 44179, which produces the Red Rectangle nebula—a known emitter of AIBs. However, no specific PAH molecules have been detected in such environments, complicating the understanding of PAH formation and evolution. This study aimed to detect the PAH molecule corannulene ($C_{20}H_{10}$), a viable candidate for radio detection due to its large dipole moment of 2.07 D. We analyzed high-resolution band 4 ALMA observations of the Red Rectangle nebula, collected over almost 9 hrs. Although corannulene emission was not detected, we estimated a firm upper limit on its abundance compared to hydrogen (5×10^{-13}) and we discuss the lack of detection in the context of our current understanding of PAH formation and destruction mechanisms. Additionally, we report tentative detection of signals at 139.612 GHz, 139.617 GHz, and 139.621 GHz, potentially originating from cyclopropenyledine (c-C_3H_2) and the 140 GHz H_2O maser.

E-mail: a.candian@uva.nl

Monthly Notices of the Royal Astronomical Society (Accepted)

https://doi.org/10.1093/mnras/staf1967
https://arxiv.org/html/2509.22370v1

Electronic Spectroscopy of C_{60}^+ and Its Analogs $C_{60}H_2O^+$, $C_{60}H^+$, $C_{60}D^+$, and $C_{60}Mg^+$

Lisa Ganner[1], Gabriel Schöpfer[1], Alexander Ebenbichler[2], Stefan Bergmeister[1], Milan Ončák[1], Helgi Rafn Hrodmarsson[3], Elisabeth Gruber[1]

[1]Institute for Ion Physics and Applied Physics, University of Innsbruck, Innsbruck, Austria
[2]Institute for Astro- and Particle Physics, University of Innsbruck, Innsbruck, Austria
[3]CNRS, LISA UMR 7583, L'Université Paris-Est Créteil, Université Paris Cité, Créteil, France

The fullerenes C_{60} and C_{70} have been detected in various interstellar environments, and the cation has been identified as a carrier of at least four of the diffuse interstellar bands (DIBs). Based on the presence of fullerenes in space, it is plausible that certain fullerene analogs are abundant in interstellar environments as well. In this context, we present the first electronic laboratory spectra of the analogs $C_{60}H_2O^+$, $C_{60}H^+$, $C_{60}D^+$, and $C_{60}Mg^+$. Furthermore, the electronic spectrum is remeasured and assignments of the observed transitions are proposed. In the spectrum of $C_{60}H_2O^+$, several distinct absorption features could be detected between 10,300 and 10,800 cm^{-1}, whereas the analogs $C_{60}H^+$, $C_{60}D^+$, and $C_{60}Mg^+$ show a broad absorption in the visible region between 17,000 and 25,000 cm^{-1}. None of the detected absorption features in these analogs could be assigned to DIBs.

E-mail: hhrodmarsson@lisa.ipsl.fr E-mail: E.Gruber@uibk.ac.at

The Astrophysical Journal **993**, 47 (2025)

https://iopscience.iop.org/article/10.3847/1538-4357/adfd50

Characterization of Two Cool Galaxy Outflow Candidates Using Mid-Infrared Emission from Polycyclic Aromatic Hydrocarbons

Jessica Sutter[1], Karin Sandstrom[2], Ryan Chown[3], Oleg Egorov[4], Adam K. Leroy[3,5], Jérémy Chastenet[6], Alberto D. Bolatto[7], Thomas G. Williams[8], Daniel A. Dale[9], Amirnezam Amiri[10], Médéric Boquien[11], Yixian Cao[12], Simthembile Dlamini[13], Éric Emsellem[14,15], Hsi-An Pan[16], Debosmita Pathak[3,17], Hwihyun Kim[18], Ralf S. Klessen, Hannah Koziol[2], Erik Rosolowsky[19], Sumit K. Sarbadhicary[20], Eva Schinnerer[21], David A. Thilker[20], Leonardo Úbeda[22], Tony Weinbeck[9]

[1]Whitman College, Walla Walla, WA, USA
[2]Department of Astronomy & Astrophysics, University of California, San Diego, La Jolla, CA, USA
[3]Department of Astronomy, The Ohio State University, Columbus, OH, USA
[4]Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Heidelberg, Germany
[5]Center for Cosmology and Astroparticle Physics (CCAPP), Columbus, OH, USA
[6]Sterrenkundig Observatorium, Universiteit Gent, Gent, Belgium
[7]Department of Astronomy and Joint Space-Science Institute, University of Maryland, College Park, MD, USA
[8]Sub-department of Astrophysics, Department of Physics, University of Oxford, Oxford, UK
[9]Department of Physics and Astronomy, University of Wyoming, Laramie, WY, USA
[10]Department of Physics, University of Arkansas, 226 Physics Building, Fayetteville, AR, USA
[11]Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France
[12]Max-Planck-Institut für Extraterrestrische Physik (MPE), Garching, Germany
[13]Department of Astronomy, University of Cape Town, Rondebosch, South Africa
[14]European Southern Observatory, Garching bei München, Germany
[15]Univ Lyon, Univ Lyon1, ENS de Lyon, CNRS, CRAL UMR5574, Saint-Genis-Laval France
[16]Department of Physics, Tamkang University, New Taipei City, Taiwan
[17]Center for Cosmology and Astroparticle Physics, Columbus, OH, USA
[18]International Gemini Observatory/NSF NOIRLab, Tucson, AZ, USA
[19]Dept. of Physics, University of Alberta, Alberta, Canada
[20]Department of Physics and Astronomy, The Johns Hopkins University, Baltimore, MD, USA
[21]Max-Planck-Institut für Astronomie, Heidelberg, Germany
[22]Space Telescope Science Institute, Baltimore, MD, USA

We characterize two candidate cool galactic outflows in two relatively low mass, highly inclined Virgo cluster galaxies: NGC 4424 and NGC 4694. Previous analyses of observations using the Atacama Large Millimeter Array (ALMA) carbon monoxide (CO) line emission maps did not classify these sources as cool outflow hosts. Using new high sensitivity, high spatial resolution, JWST mid-infrared photometry in the polycyclic aromatic hydrocarbon (PAH)-tracing F770W band, we identify extended structures present off of the stellar disk. The identified structures are bright in the MIRI F770W and F2100W bands, suggesting they include PAHs as well as other dust grains. As PAHs have been shown to be destroyed in hot, ionized gas, these structures are likely to be outflows of cool ($T \leq 10^4$ K) gas. This work represents an exciting possibility for using mid infrared observations to identify and measure outflows in lower mass, lower star formation galaxies.

E-mail: sutterjs@whitman.edu

The Astrophysical Journal Letters **922**, 001 (2025)

https://iopscience.iop.org/article/10.3847/2041-8213/ae08b7/
https://arxiv.org/abs/2509.12058

Announcements

Laboratory Astrophysics Newsletter

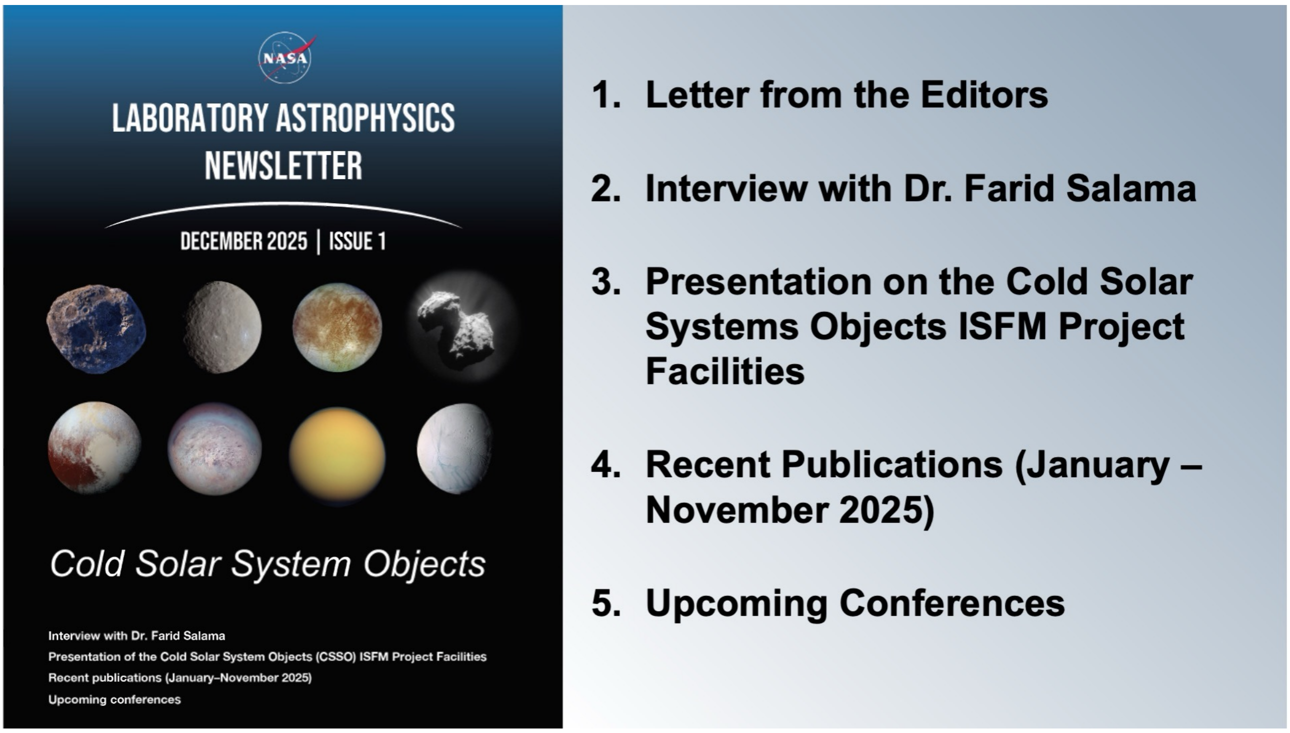
Advertised by

Ella Sciamma-O'Brien, Michel Nuevo, Partha Bera,
Lora Jovanovic, Joe Roser, Aaron McKinnon

Following in the footsteps of AstroPAH and other newsletters, we are excited to present the **Laboratory Astrophysics Newsletter**, whose goal is to enhance communication and interactions between experimentalists, theoreticians, modelers, and observers in the fields of Astrophysics and Planetary Science around the world.

The Laboratory Astrophysics Newsletter is intended to be released quarterly. Each issue will focus on a particular theme in the Laboratory Astrophysics field and include sections such as a cover image, a scientist interview, a description of facilities, recent publications in the field, and/or announcements for upcoming meetings.

The theme of the first issue is Cold Solar System Objects. Check it out here!



Cover and contents of the Laboratory Astrophysics Newsletter's first issue.

In future issues, we look forward to featuring various Laboratory Astrophysics themes and include interviews of scientists and presentations of facilities around the world.

We welcome contributions. You can share publications and announcements through our contribution form, and join our mailing list or contact us at labastronewsletter@mail.nasa.gov.

Keep an eye out for our next issue, in March 2026, and please let us know what you would like future themes to be or if you would like to contribute!

AstroPAH Newsletter

http://astropah-news.strw.leidenuniv.nl
astropah@strw.leidenuniv.nl

Next issue: 18 December 2025
Submission deadline: 05 December 2025