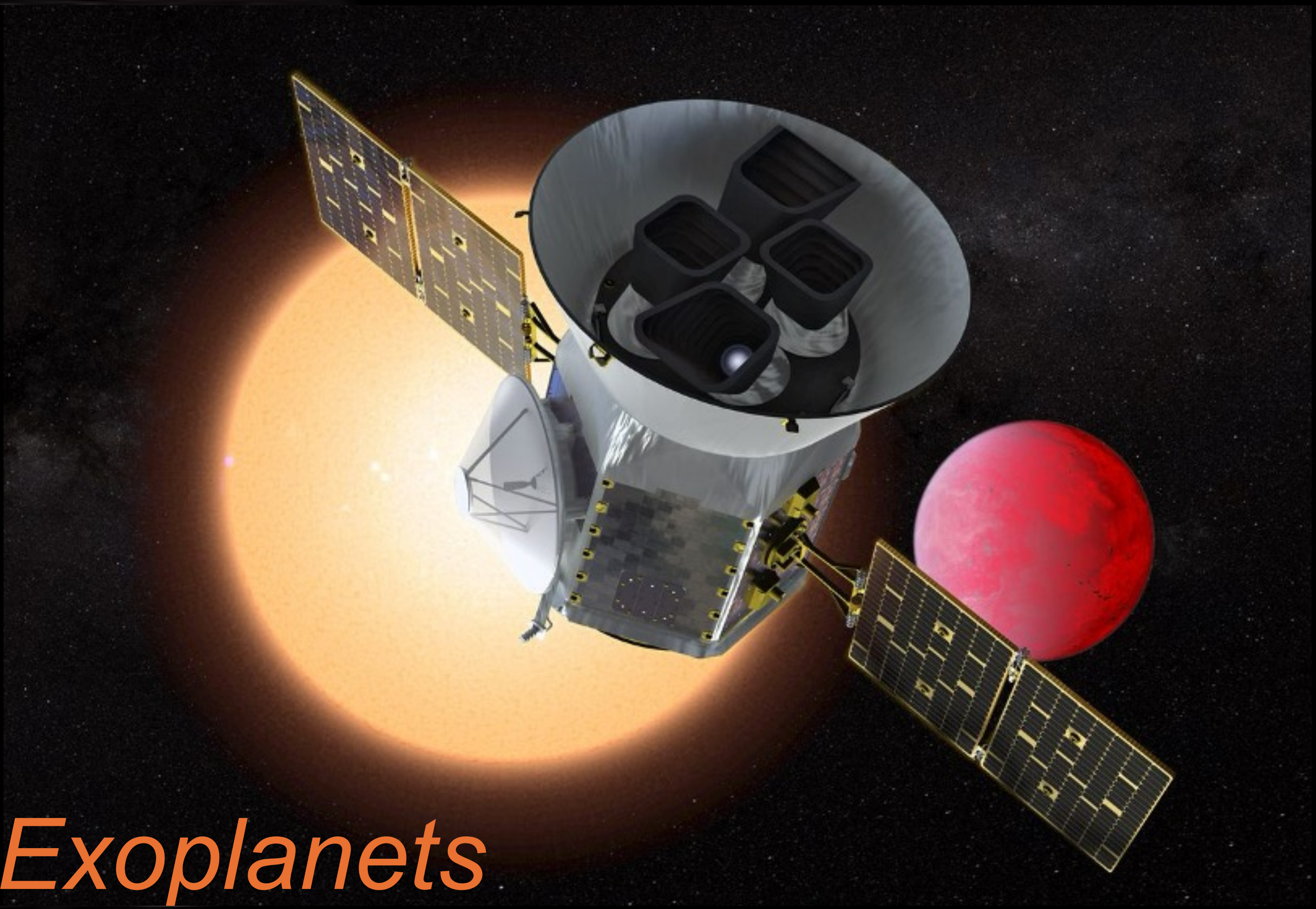
LABORATORY ASTROPHYSICS NEWSLETTER

MARCH 2026 | ISSUE 2



Exoplanets

Exoplanets in numbers & fun facts

Interview with Dr. Peter Gao

Presentation of laboratory facilities

Recent publications (December 2025 – March 2026)

Upcoming conferences

Image credits: NASA's Goddard Space Flight Center

Letter from the Editors

Welcome to the second issue of the Laboratory Astrophysics Newsletter!

The goal of this newsletter is to enhance communication and interactions between experimentalists, theoreticians, modelers, and observers in the fields of Astrophysics and Planetary Science around the world.

This second issue of the Laboratory Astrophysics Newsletter focuses on **Exoplanets**.

On the cover page, we show an artist impression of an exoplanet orbiting its star and NASA's Transiting Exoplanet Survey Satellite (TESS) which launched in 2018 and has identified so far more than 7,800 candidate exoplanets.

We have added a new section in this issue to provide ***numbers and fun facts*** related to Exoplanets. It is followed by an ***interview with Dr. Peter Gao***, a research scientist at the Earth and Planets Laboratory of the Carnegie Institution for Science who has been studying exoplanet atmospheres for the last decade.

In the ***Laboratory Facilities*** section, we present three laboratory facilities that simulate the chemistry in exoplanet atmospheres and/or characterize the physical and spectral properties of exoplanet aerosol analogs.

Our ***Publications*** section covers the broad laboratory astrophysics field and includes work published since December 2025.

Finally, the ***Meetings*** section provides a list of upcoming meetings relevant to the field of Planetary Science and Astrochemistry.

We hope you enjoy reading our newsletter and we encourage you to visit our newsletter website for current and past issues here.

Joseph Roser

Ella Sciamma-O'Brien

Lora Jovanovic

Michel Nuevo

Partha Bera

Aaron McKinnon

As mentioned in Dr. Gao's interview, extensive experimental work is needed to provide critical data for the interpretation of observational data and gain a better understanding of exoplanet atmospheres and interiors. We plan to have another issue in the future on the matter and highlight other facilities. Please contact us if you would like your facility to be featured.

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

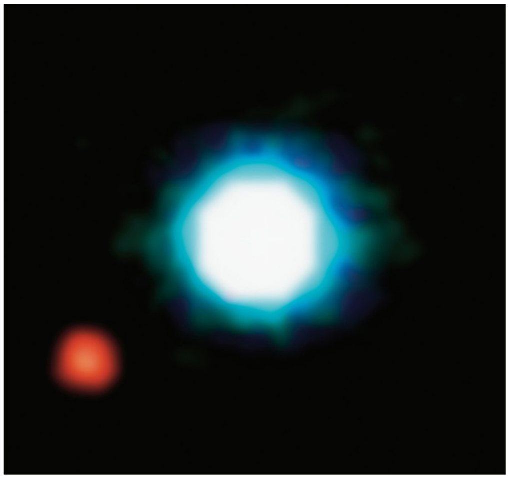
We publish quarterly; keep an eye out for our next issue!

The Editorial Team

Exoplanets in Numbers & Fun Facts

Exoplanets in Numbers

1992	First detection of two planets orbiting a pulsar
1995	First detection of exoplanet around a Sun-like star
2004	First direct image of an exoplanet: 2M1207b imaged with the VLT



Composite image showing exoplanet 2M1207b (red spot on the ***lower left****), orbiting the brown dwarf 2M1207 (****center****). Credit: ESO*

6153	Confirmed exoplanets as of 2026/03/30 (**2076** Neptune-like, **2065** Gas Giant, **1782** Super Earth, **223** Terrestrial, and **7** Unknown)
> 8000	Exoplanet candidates awaiting confirmation
0	Exomoons detected
1	Extrasolar comet detected
4.2	Distance, in light-years, to the closest exoplanet Proxima Centauri b (also known as α-Centauri Cb)

Exoplanets – Fun Facts

Types of exoplanets

Neptune-like: Planets similar in size to Uranus and Neptune, possessing an atmosphere rich in hydrogen (H_2) or helium (He).

Gas Giants: Planets similar in size to Jupiter or Saturn or even larger, orbiting close to their stars. This category of exoplanets includes “hot Jupiters”.

Super Earths: Rocky planets with sizes between that of Earth and Neptune.

Terrestrial: Planets made of rock or metal with sizes smaller than Earth’s, possibly possessing an ocean and/or an atmosphere.

Exoplanet detection methods

73.5%	**Transit**
19.2%	**Radial velocity**
4.5%	**Gravitational microlensing**
1.5%	**Direct imaging**
1.3%	**Other** (transit timing variations, eclipse timing variations, orbital brightness modulation, pulsar timing, astrometry, pulsation timing variations, disk kinematics)

Section header image credits: NASA/ESA

Interview with Dr. Peter Gao

Astronomer at the Carnegie Institution for Science

Peter Gao received his PhD in Planetary Science from Caltech in 2017. He then moved to the San Francisco Bay Area as a NASA Postdoctoral Program (NPP) Fellow at NASA Ames Research Center, working on exoplanet and brown dwarf cloud modeling, followed by three years at UC Berkeley, as one of the inaugural 51 Pegasi b Postdoctoral Fellows, where he continued his investigation of exoplanet clouds and hazes. After three years, he was offered the NHFP Sagan Fellowship at UC Santa Cruz, where he spent one year before moving to the Washington DC area to become a permanent staff scientist at the Earth and Planets Laboratory of the Carnegie Institution for Science.

How did you get into exoplanet research?

I started my career as a graduate student at Caltech studying clouds and hazes (aerosols) in the atmospheres of Venus, Titan, and Pluto. Specifically, I modeled the microphysical processes — nucleation, condensation, evaporation, and coagulation — that controlled their formation and their size and spatial distributions. As I neared the end of my PhD program, however, I noticed an interest from the community in more exotic clouds and hazes in exoplanet atmospheres and how they affected the interpretation of exoplanet data. At the time, most of the models used to simulate such clouds and hazes were simplified and lacked predictive power. Working with an exoplanet scientist at Caltech, I applied my micro-physics model to exoplanet clouds and hazes to predict their distribution from first principles, and found a diverse set of behaviors depending on the specific cloud and haze material and the background atmospheric state.

I continued to pursue this topic into my postdoc years at NASA Ames, UC Berkeley, and UC Santa Cruz, eventually constructing a standard microphysics model for condensate clouds in atmospheres dominated by hydrogen and helium, which I applied to explain the cloudiness trend in hot and warm Jupiters (cf. **Figure 1**). In 2021, I started my permanent position as a staff scientist at the Earth and Planets Laboratory of the Carnegie Institution for Science, where I expanded beyond exoplanet cloud and haze research into interpretation of exoplanet atmospheric data from the *James Webb Space Telescope* (*JWST*).

What is your current research about?

My current research focuses on understanding the formation and evolutionary processes of the exoplanet population through modeling of atmospheric observations from *JWST* (cf. **Figure 2**). I use a suite of tools, including retrievals, radiative–convective equilibrium forward models, photochemical models, and aerosol micro-physics models to interpret transmission and emission spectra from *JWST* of a range of planets, from rocky worlds to gas giants. My specific interests lie in three topics: (1) the nature of extremely young (<100 Myr) planets, which can tell us about the initial conditions of planet evolution, (2) connecting system architecture to the atmospheric composition of giant planets, which can better constrain their formation processes, migration scenarios, and dynamical histories than just knowing their atmospheric composition alone, and (3) atmo-

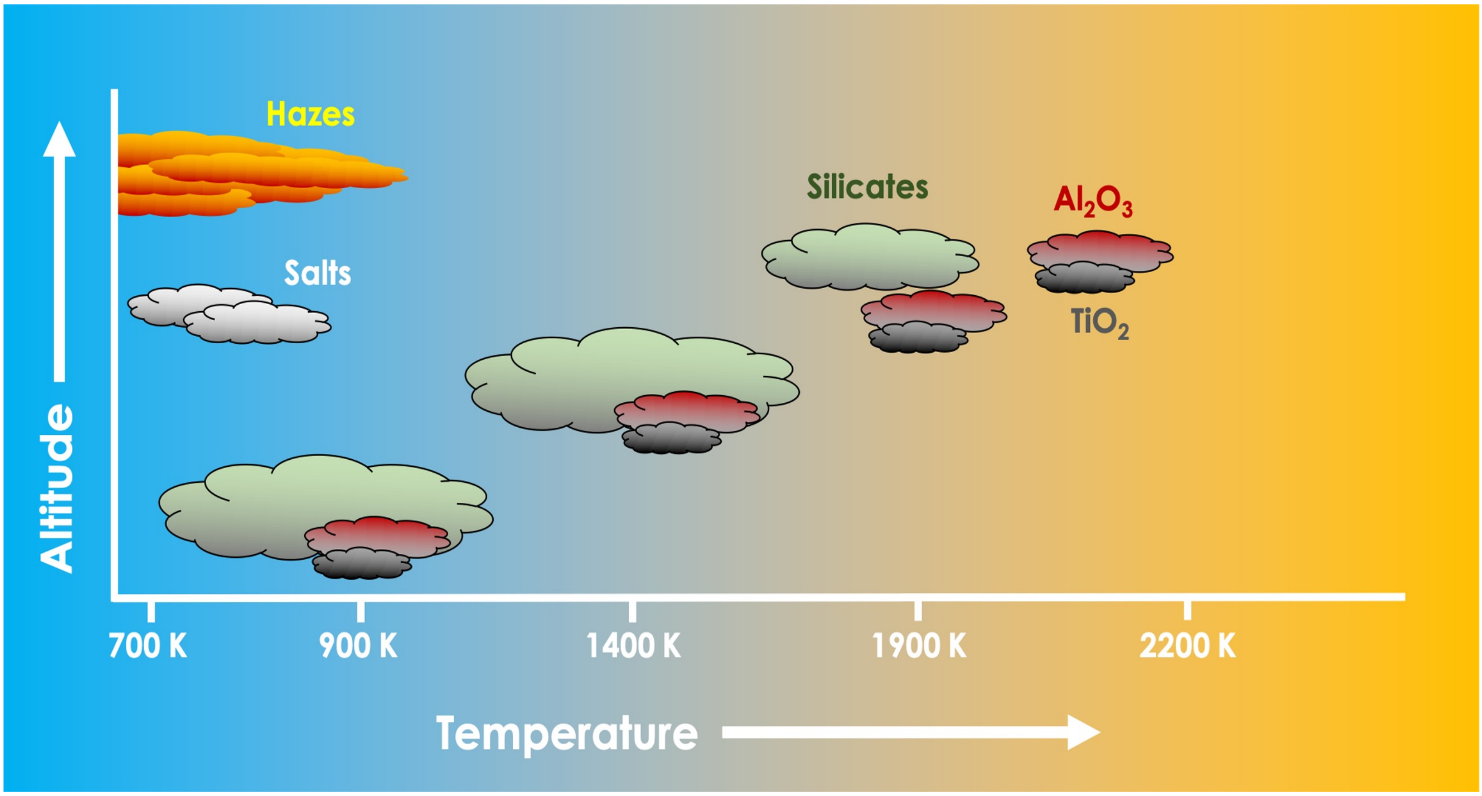


Figure 1. *Predicted cloud altitudes and compositions for a range of temperatures common on hot Jupiter planets (from U.C. Berkeley press release, May 2020).*

sphere–interior interactions of sub-Neptunes, which can greatly affect the observed atmospheric state and offer clues to the nature of this enigmatic population.

A lot of my present motivation and joy in my research stems from the flood of new data we are getting, not just from *JWST*, but also from ground-based facilities capable of high-contrast and high-spectral-resolution observations. As a Co-I on several *JWST* programs, I have the privilege of seeing connections between different datasets made possible by the shared laws of physics and chemistry that control these planets' atmospheres. It is an awesome feeling seeing what was predicted decades ago falling into place, a feeling only eclipsed by seeing the unpredicted, which happens often and leads to brand new questions to explore.

How has the field of exoplanet research evolved since you started your career?

When I started graduate school in 2010, the discoveries of the Kepler mission were only a few months old and atmospheric characterization of exoplanets were limited to mostly photometry and low-resolution spectroscopy of hot Jupiters. The predictions of models far outpaced what could be tested with the available data. Since then, the field has grown exponentially in both research and people. Models became more sophisticated — and also open — more publicly available codes arrived on the scene, allowing more people, especially junior scientists, to make substantial contributions. With the launch of *JWST* and development of new ground-based instruments, we are now finally able to test the myriad of predictions from chemical, dynamical, and aerosol models that have been applied across the exoplanet population. The bottleneck is no longer just the astronomical data, but rather the accuracy of the models and the lack of important experimental data as well, prompting a new push to solve these issues. In addition, smaller planets, including sub-Neptunes and rocky planets, are now a major focus thanks to the improved ability to observe them, but both the observational data and models of their atmospheres and interiors are still in their infancy. It's a very exciting time!

How has your research impacted the field?

I like to think that I made a significant contribution to the study of clouds and hazes in exoplanet atmospheres and helped promote the use of microphysical models in interpreting exoplanet data. During my career I saw clouds and hazes evolve from a nuisance that plagued datasets to a major subfield of study in exoplanet science, and I hope I played a positive role in making that happen.

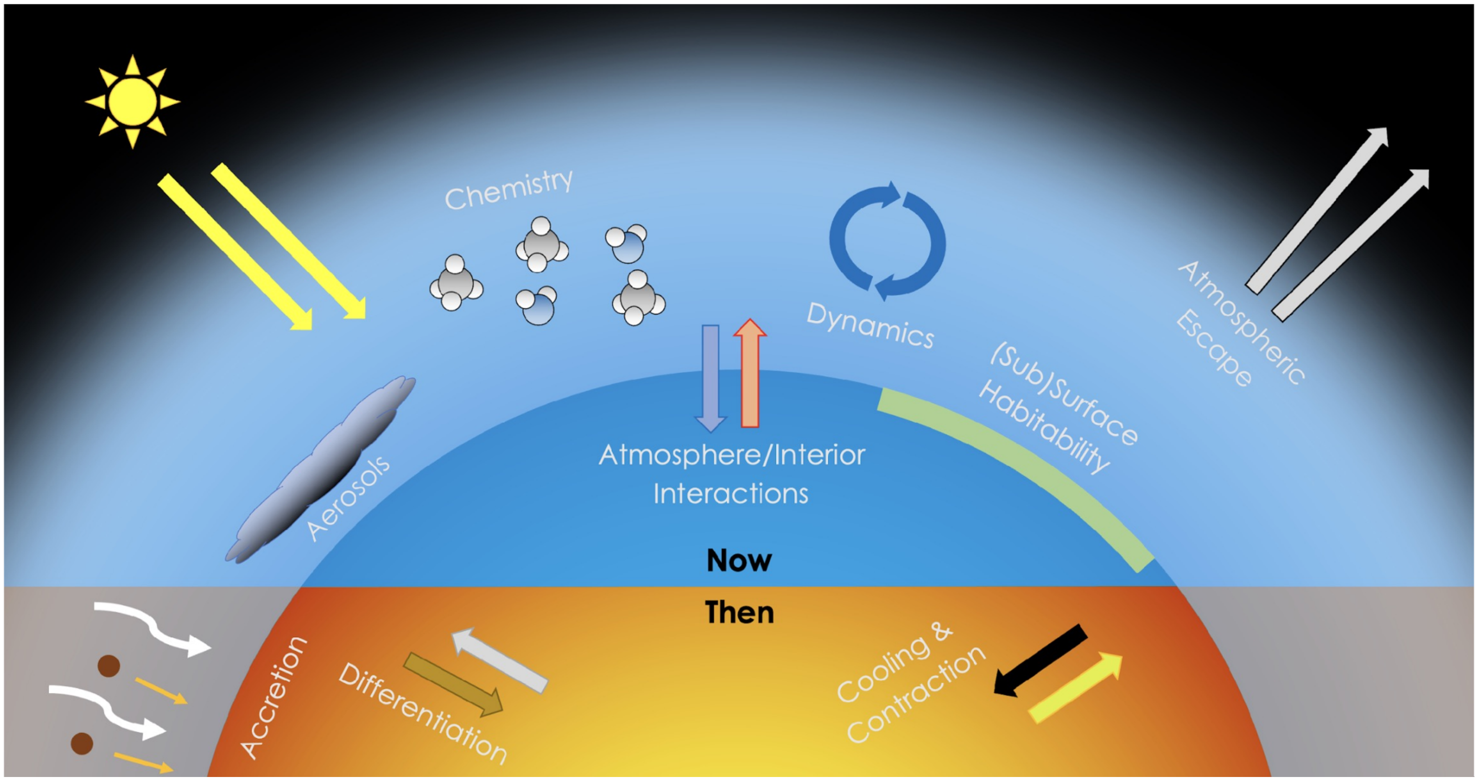


Figure 2. *Physical and chemical processes that impact the current and past states of planetary atmospheres that our current observations can probe.*

Which open question in exoplanet research would you like to see answered?

I would like to see the nature of sub-Neptunes revealed in the near future. Given their abundance in the exoplanet population, not knowing what they really are, or how they came to be, seems like a major problem. Luckily this problem is being attacked from multiple fronts, through astronomical observations, advanced models, and laboratory work. With their powers combined I think it would be just a matter of time before we can say something fundamental about them as a population. Meanwhile, I think we are close to "solving" giant exoplanets in terms of their origins, migration pathway, and atmospheric state. Between system architecture measurements (e.g. spin-orbit alignment, planet multiplicity, eccentricity distribution, etc.), atmospheric composition data, and investigations into their atmospheric chemistry, dynamics, and aerosol content through space and ground-based spectroscopy, I think we can soon — within the next decade I hope — say how hot, warm, and cold exo-Jupiters come to be and evolve over Gyr timescales.

What do you consider to be important laboratory astrophysics data still needed for exoplanet research?

We desperately need more laboratory studies in exoplanet science!! There are fundamental problems in the field that can only be solved through experimental research.

I would divide the necessary work into those that support models and astronomical observations, and those that offer unique insights that neither models nor observations can provide. In the former category are measurements of gaseous opacities and chemical reaction rates at a wide variety of pressures, temperatures, and compositions (especially sulfur!!) that control the results of radiative-convective equilibrium and photochemical models. In the latter category are (1) high pressure experiments that can directly tell us the conditions in the interiors of sub-Neptunes and giant planets, including how various materials mix, and (2) direct experimental simulation of aerosol formation through condensation of a mix of species (e.g., Mg, SiO, Fe, Al) and gradual generation of haze particles through chemical reactions; these are vital in helping us understand what the formation pathways of aerosols are in exoplanet atmospheres.

What was the most important advice somebody gave you?

It's ok to say no to things, but at the same time it's an artform to recognize great opportunities from not-so-great ones.

Do you have any advice for early-career scientists interested in exoplanet research?

I would say that this is an extremely exciting time to enter the field given the current flood of data and the promise of an even greater deluge of data to come from *Gaia*, the *Roman Space Telescope*, and the *Extremely Large Telescopes* (*ELTs*), and that there are way more questions than there are people working on them. Exoplanet science is such a young and developing field that merely scratching the surface would reveal major mysteries. For example, what is even a sub-Neptune? We still don't have a good idea on a population level. In terms of specific advice, I think one should keep note of the latest discoveries in exoplanet science, but also immerse oneself in related fields, such as Solar System and stellar science, which could inspire new ways to look at mysteries in exoplanet science that are already well known in those fields. My work in applying aerosol microphysics to exoplanets is a perfect example of this. Exoplanet science is becoming more and more interdisciplinary every day and having a wide base of knowledge across astrophysics, planetary science, and Earth science will be helpful for making sense of the observations to come.

What inspired you to become a scientist?

I wanted to study geology and astronomy since I was a kid when I was given children's books on those topics filled with images of landforms and planets, the latter taken by the *Voyager* probes. Years later I got to thank Ed Stone, the Project Scientist of the *Voyager* missions, in person for his inspiring work at a DPS meeting, which was pretty neat. I would say watching folks like Carl Sagan when I was a teen was also impactful in making me want to test my assertions instead of just believing them.

How do you balance your professional and personal life?

It's very difficult! I have young kids so when I am not working, I am taking care of them and all the other chaotic things that happen in a family with young kids. I very much feel like I am flying through life by the seat of my pants, hopping from one thing to another with no real firm trajectory, but it seems to have worked out so far in life and work, thanks to my supportive partner and colleagues. It's chaos but also thrilling and rewarding!

Laboratory Astrophysics Facilities:

Laboratory Facilities Studying Exoplanets

In this second issue of the Laboratory Astrophysics Newsletter, we present three laboratory facilities that are used to conduct experimental work connected to Exoplanet Research: the Planetary Haze Research (PHAZER) Chamber at Johns Hopkins University, the Planetary Material CHaractErization Facility (PMCHEF) at the University of Texas at San Antonio, and the Cell for Atmospheric and Aerosol Photochemistry Simulations of Exoplanet (CAAPSE) facility at NASA Jet Propulsion Laboratory.

PHAZER Chamber at Johns Hopkins University

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PMCHEF Facility at University of Texas San Antonio

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CAAPSE Facility at NASA Jet Propulsion Laboratory

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Check also the **COSmIC, OCF**, and **MIOCI** facilities in the Laboratory Astrophysics Newsletter issue 1, which are used to produce and characterize exoplanet aerosol analogs.

Section header image credits: Wendy Stenzel/NASA/JPL

PHAZER Chamber at Johns Hopkins University

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The Planetary HAZE Research (PHAZER) chamber was designed to simulate photochemistry under a wide range of planetary conditions. The chamber, in tandem with other instruments, provides ground truth measurements to aid observations. We are broadly interested in atmospheric chemistry, the formation of aerosols, how aerosols shape a planet's surface, and astrobiology.

Laboratory Facilities

PHAZER chamber

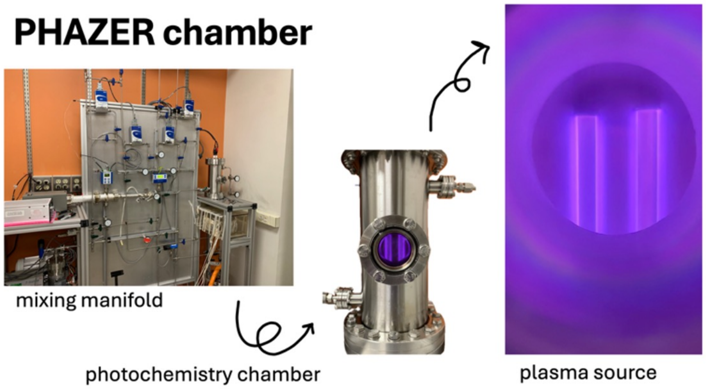
Atmospheres are simulated with custom gas mixtures (N_2, H_2, He, Ar, O_2, CH_4, CO, CO_2, H_2O, NH_3, H_2S, SO_2 so far) warmed or cooled to a desired temperature (80 to 800 K). The mixture flows through a stainless-steel chamber at upper atmosphere pressures (from 0.001 to 10 mbar), where they are exposed to an energy source (UV lamp, AC cold plasma). Photochemical reactions produce solid products, or photochemical haze analogs, that can be collected for physical, optical, and chemical property measurements.

Residual gas analyzer (RGA)

The RGA monitors gas-phase composition up to 300 m/z throughout a PHAZER experiment.

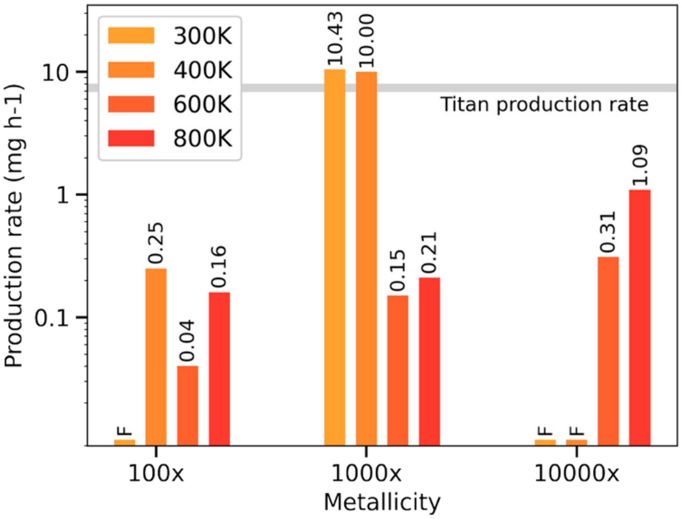
Fourier-transform infrared spectrometer (FTIR)

The FTIR measures optical properties from 0.4 to 28.5 µm, using various techniques such as KBr pellets, variable angle reflectance, and attenuated total reflectance depending on the sample and use case. These measurements are crucial for deriving the optical constants (complex refractive indices) of aerosols including haze analogs produced with PHAZER and cloud analogs made from aqueous solutions.



Haze formation and evolution in temperate exoplanet atmospheres

Observations of super-Earths and sub-Neptunes, the most common types of planets, suggest high altitude aerosols in their atmospheres. Haze properties are poorly understood, and models lack the complexity to capture the true nature of these particles. We conducted laboratory investigations into the effects of atmospheric metallicity from 100 to 10,000× solar and temperature from 300 to 800 K on photochemical hazes.

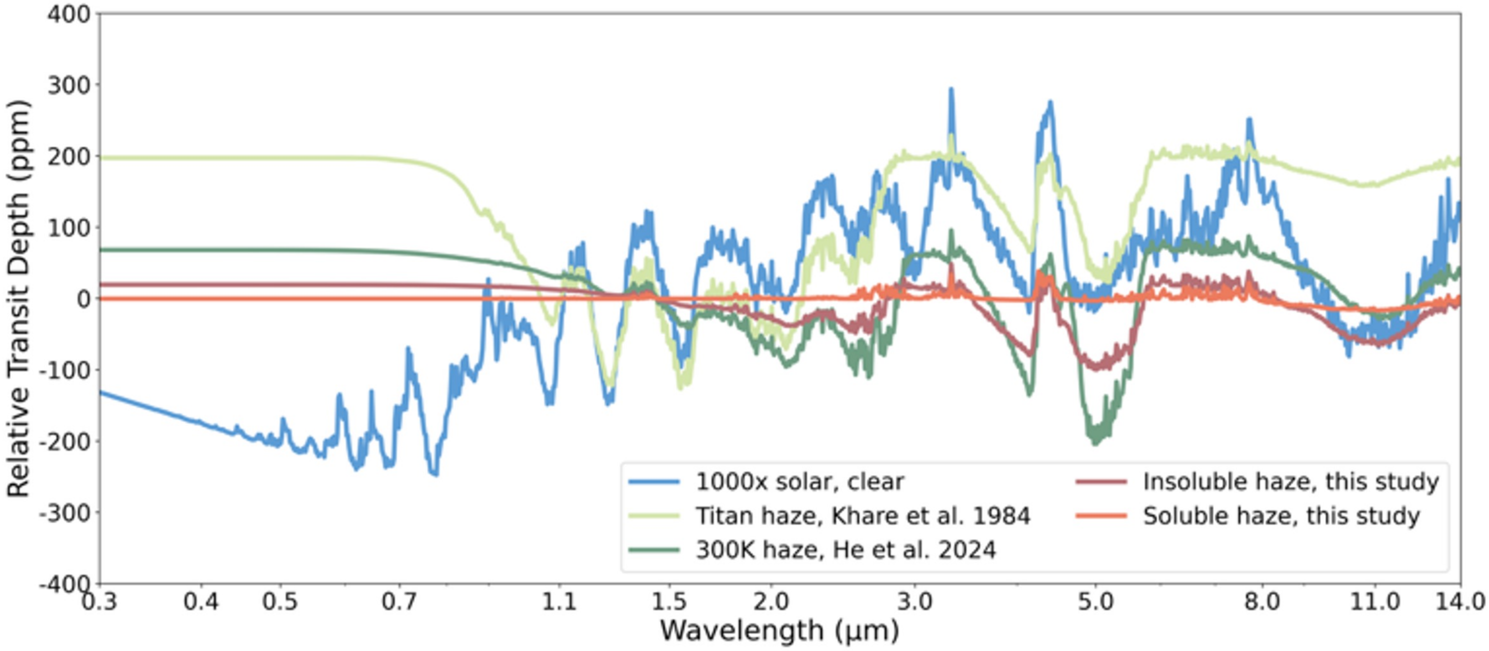


The 300 and 400 K 1000× solar metallicity, or water-rich, atmospheres had the highest haze production rates (Hörst et al. 2018; He et al. 2020a, 2020b).

The high production rates observed for cooler water-rich exoplanets offer an opportunity to investigate how hazes evolve in their environment, especially in the presence of liquid water. The haze analogs have high upper-limit solubilities, suggesting they are efficient cloud condensation nuclei and have evolved physical, optical, and chemical properties.

Aiding observations with laboratory data

Interpretations of exoplanet observations depend critically on model inputs and assumptions. With the huge parameter space of environments on discovered exoplanets, a limiting factor is often the availability of relevant laboratory measurements. The photochemistry experiments from PHAZER help fill these gaps.



Synthetic transmission spectra demonstrate how haze optical properties can greatly influence the interpretation of data (Khare et al. 1984; He et al. 2024; Pesciotta et al. 2026a).

Optical constants

The real and imaginary refractive indices describe how particles absorb and scatter light in an atmosphere. This affects radiative transfer with consequences for the planet's transmission and reflectance spectra.

Gas-phase chemistry

In PHAZER exoplanets experiments, gas-phase reactions produced molecules like C_2H_2, HCN, CH_2NH, and HCHO, which may be precursors for haze formation. Each simulated atmosphere had distinct chemistry. All experiments produced organic molecules, and some even produced O_2, suggesting that there are abiotic pathways for these potential biosignatures (He et al. 2018a).

Particle size distribution

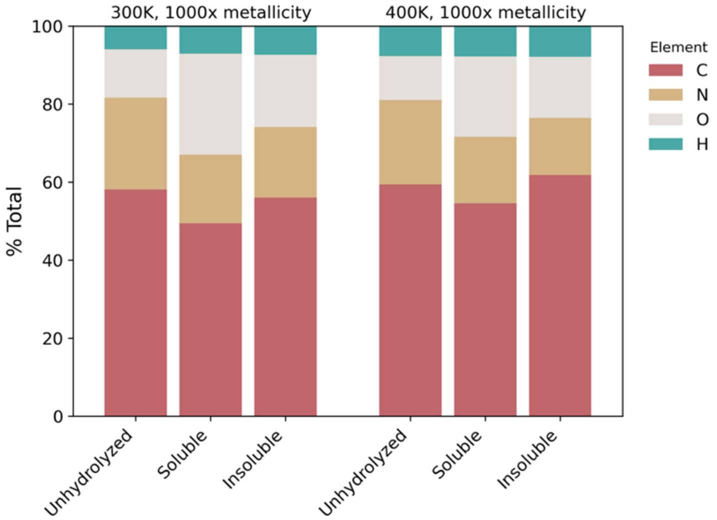
The sizes of aerosol particles greatly affect how they interact with light, having large influences on temperature structure and observed spectra. In the PHAZER exoplanet experiments, each condition produced haze analog particles that varied in size. These measurements can be used as modeling inputs (He et al. 2018b).

A closer look at far away worlds

As opposed to solar system science, exoplanet science relies on remote sensing without help from *in situ* measurements. Instead, laboratory experiments can detail the smaller processes occurring on exoplanets that are not accessible via remote sensing (yet).

Chemical composition

High-resolution mass spectrometry reveals incredibly complex chemistry, including detections of the molecular formulas for many prebiotic molecules.



The hydrolyzed samples show increased oxygen incorporation, potentially producing dipeptides and complex sugars (Moran et al. 2020; Pesciotta et al. 2026b).

Surface energy

Bulk material properties like surface energy describe transport through the atmosphere. Surface energy measurements of haze analogs show temperature-dependent trends, having consequences for habitability and observability (Yu et al. 2021).

PMCHEF Facility at University of Texas San Antonio

Xinting Yu (Xinting.Yu@utsa.edu), Jose Raul Montes Bojorquez, Sara Port, Eito Hirai, Adis Husic, Cindy Luu, Eric Austin, Elizabeth Bartelt, Ricardo Vega, Reggie Delaney Kaylee Dobiyansk
https://xintingyu.com/my-lab-at-ucsc/

The Planetary Material CHaractErization Facility (PMCHEF) at the University of Texas at San Antonio is dedicated to measuring the fundamental physical properties of planetary materials at nano- and micro-scales. Our goal is to connect laboratory-scale measurements to atmospheric, surface, and interior processes operating in Solar System bodies and exoplanets. By combining controlled-environment experimentation with advanced materials characterization tools, we bridge laboratory astrophysics, planetary science, and materials physics.

All core instrumentation operates under controlled dry nitrogen (ppm-level water vapor and oxygen gas) or vacuum environments to preserve chemically sensitive astromaterials and prevent contamination. This infrastructure enables reliable measurements of volatile-rich organics, aerosol analogs, and reactive materials relevant to planetary environments. In parallel with fundamental research, PMCHEF evaluates advanced engineered materials under space-relevant conditions, supporting technology development for future missions.

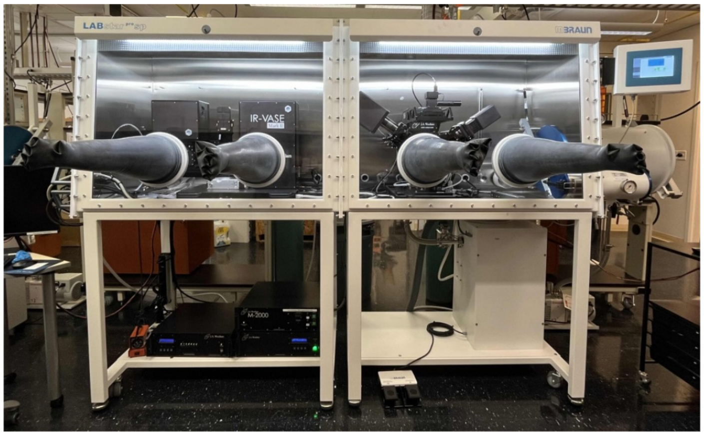
Optical Property Characterization

Dual Spectroscopic Ellipsometer

PMCHEF houses a dual J. A. Woollam spectroscopic ellipsometry (SE) system (M-2000 and IR-VASE), covering wavelengths from 0.19 to 30 µm. It is enclosed within a glovebox maintained below 1-ppm H_2O and O_2.

This SE system is used to determine the complex refractive index (*n* and *k*) of thin films by measuring both amplitude and phase changes of polarized light upon reflection. Because phase information is highly sensitive to film thickness, the system enables accurate optical constant retrieval for layers only a few nanometers thick.

PMCHEF's capability complements existing optical constants facilities, which are optimized for films (~100 nm or more) and powders. PMCHEF excels at measuring thin photochemical and plasma-generated films, including haze analogs relevant to Titan and exoplanet atmospheres. These measurements provide direct inputs to radiative transfer models to help interpret spacecraft and telescopic observations.



The dual-ellipsometry system is housed within a glovebox system that maintains less than 0.5 ppm of H_2O and O_2.

Mechanical Property Characterization

KLA iMicro Nanoindenter in Dry-N_2 Glovebox

The nanoindentation system measures elastic, plastic, and fracture properties of small-volume samples, including thin films, grains, and powders. Operating in a controlled dry nitrogen environment prevents hydration and oxidation effects during measurement. Using continuous stiffness measurement (CSM), the instrument applies a harmonic oscillatory load during indentation, allowing depth-dependent mechanical properties to be determined from a single indent. This enables high-resolution mechanical profiling at nanometer scales.

This mechanical property characterization bench has been actively used to study various astromaterials, including (1) Titan's organic sand analogs to understand sediment transport and evolution of organic materials on Titan's surface, (2) organics extrapolated from meteorites, relevant to tidal deformation processes in the interiors of icy moons in the outer Solar System, and (3) complex organic molecules (COM), with implications for grain growth in protoplanetary disks. We hope to use the system to study various return planetary samples.

The nanoindentation system is housed within a glove box system that maintains less than 0.5 ppm of H_2O and O_2.

Surface, Mechanical, and Electrical Property Characterization

Scanning Probe Microscope (SPM)

PMCHEF operates a Bruker Dimension Icon Scanning Probe Microscope capable of measuring surface morphology, nanomechanical response, adhesion, cohesion, tribocharging behavior, and dielectric properties.

PeakForce Quantitative Nanomechanical (QNM) mapping enables sub-nanometer spatial resolution of mechanical and adhesive properties across individual grains. Single-grain cohesion measurements provide constraints on interparticle forces relevant to sediment transport, aerosol aggregation, and regolith evolution. Electrical and dielectric measurements further allow investigation of charging behavior in organic and aerosol analogs, a process relevant to planetary atmospheres and dust environments.

Surface Energy and Wettability Characterization

Contact Angle Goniometer and Tensiometer

The surface property characterization bench includes an Ossila contact angle goniometer and a pendant-drop tensiometer, which can be used to measure the surface tensions of liquids, surface energies of solids, and contact angles and wetting behavior of materials. This is the first instrument of PMCHEF, which was built during the PI's postdoc, a simple but powerful system to measure the intrinsic surface properties of thin-film samples that allows us to study wetting behaviors in planetary atmospheres, on planetary surfaces, and in protoplanetary disks.

Thermal Property Characterization

Dynamic vacuum furnace and vapor sorption

A home-built dynamic vacuum furnace and vapor sorption system is capable of tracking the thermal behaviors of solid materials from room temperature to 1200°C and also allows in-situ analysis of the volatiles using an ExTorr Residual Gas Analyzer (RGA). A range of gases can also be introduced via mass flow controllers, which allows us to study the solid-gas interaction *in situ*. We have used this system to address fundamental science questions, such as the evolution of primordial organic materials in planetary interiors and aerosol–gas interactions relevant to exoplanet atmospheres. It also allows us to evaluate advanced engineered materials for space-relevant applications.

The thermal property characterization bench: a home-built dynamic vacuum furnace and vapor sorption system at UT San Antonio.

CAAPSE Facility at NASA Jet Propulsion Laboratory

Murthy S. Gudipati (gudipati@jpl.nasa.gov), Bryana L. Henderson, Benjamin Fleury, Jeehyun Yang

The Cell for Atmospheric and Aerosol Photochemistry Simulations of Exoplanets (CAAPSE) is a laboratory facility designed to experimentally investigate the photo- and thermochemical environments of various exoplanet atmospheres. Developed at the Jet Propulsion Laboratory (JPL), CAAPSE enables controlled studies of how ultraviolet (UV) radiation (mainly Lyman-α) and high temperatures (up to 1800 K) influence planetary atmospheric chemistry and aerosol formation.

Key components

High-temperature reaction cell

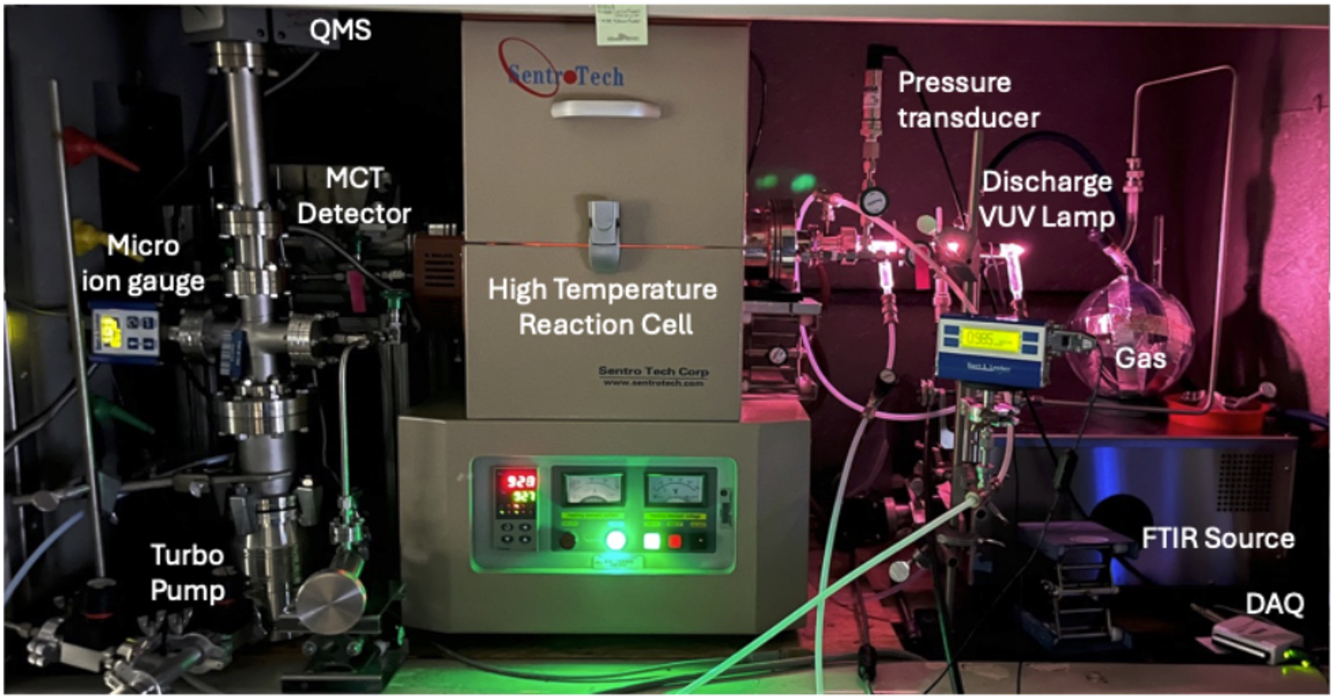
The reaction cell is used to maintain reaction temperatures from 300 to 1800 K while simultaneously allowing UV irradiation. The reaction cell is placed inside a furnace and is approximately 48 cm long with an internal diameter of about 6.1 cm, providing a long optical path suitable for Fourier-transform infrared (FTIR) measurements. Two types of reaction cells are available: a quartz tube and an alumina tube. The quartz tube minimizes wall reactions but is limited to temperatures below 1100 K, whereas the alumina tube can withstand temperatures up to 1800 K but may introduce more wall reactions.

The reaction cell is sealed with magnesium fluoride (MgF_2) windows, which transmit both vacuum ultraviolet (VUV) radiation and IR wavelengths used for spectroscopic diagnostics. To protect the MgF_2 windows from thermal damage, they are actively water cooled, while the central region of the reaction cell is heated by the furnace to temperatures up to 1800 K. These conditions allow CAAPSE to simulate the extreme environments of close-in exoplanets such as hot Jupiters (Fleury et al. 2019, 2020, 2023).

To investigate aerosol formation, sapphire substrates can be placed inside the reaction cell to collect condensed particles formed during irradiation experiments. After each experiment, the substrates are removed and analyzed spectroscopically to determine the chemical composition of the solid products.

FTIR spectroscopy system

The FTIR system is used to continuously monitor the gas-phase composition inside the reaction cell while it is heated by the furnace. A collimated IR beam passes through the heated gas mixture and is detected by an external, cryogenically cooled mercury–cadmium–telluride (MCT) detector. This set-up enables the identification and quantification of

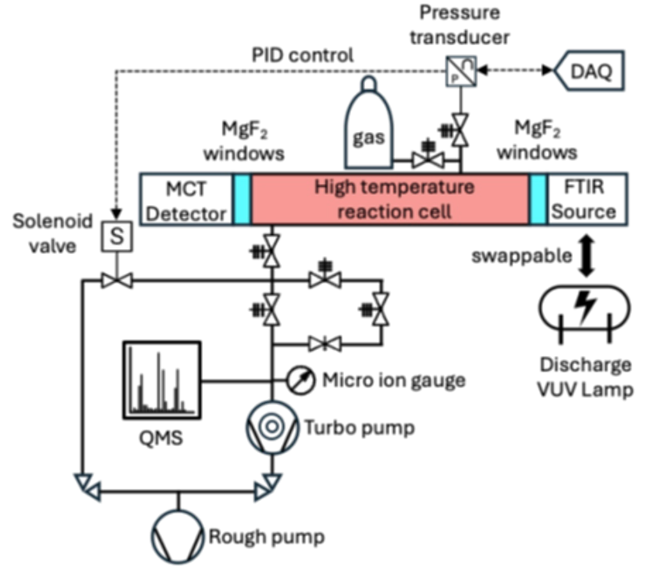


The Cell for Atmospheric and Aerosol Photochemistry Simulations of Exoplanets (CAAPSE).

molecular species based on their characteristic IR absorption features.

Quadrupole mass spectrometer (*QMS*)

The QMS is used to measure gas composition and trace species. Gas samples are transferred from the reaction chamber through a controlled leak valve and analyzed across a broad mass range, enabling sensitive detection of molecular fragments and isotopic species.



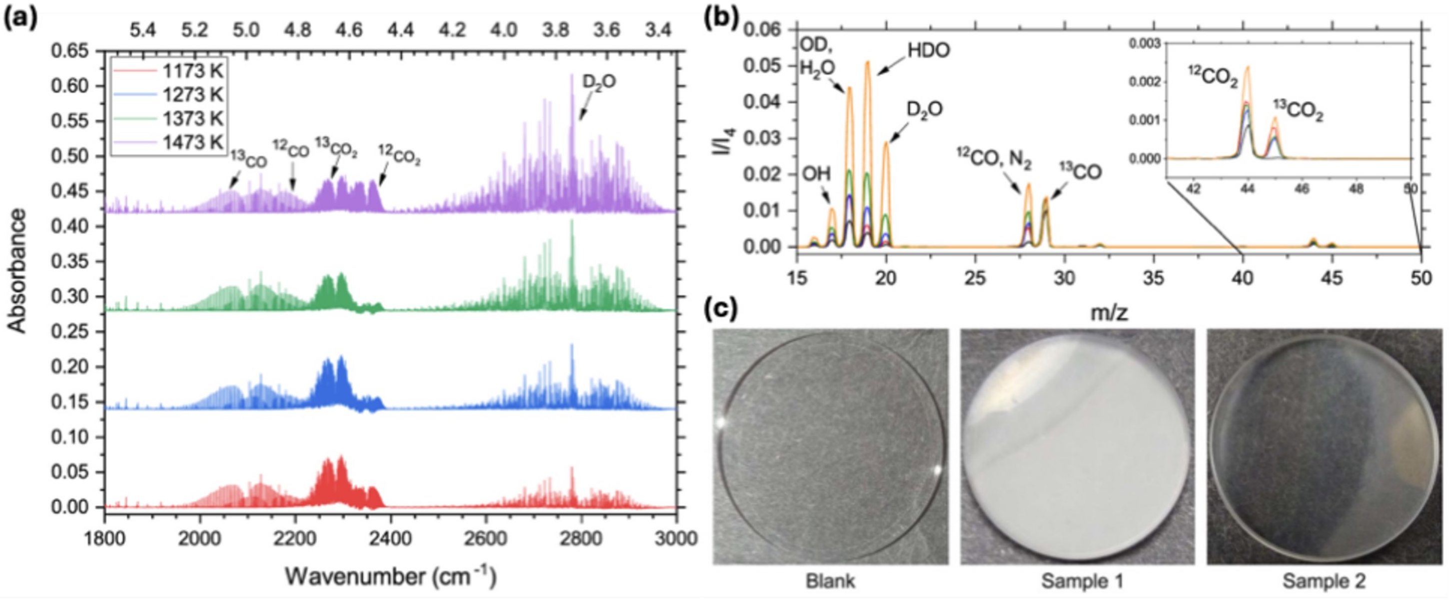
A schematic diagram of CAAPSE (adapted from Fleury et al. 2019).

Proportional-integral-derivative (PID) control system

The PID allows flow-through constant-pressure operations. In addition to the static cell reaction configuration, CAAPSE can also support flow-through experiments under constant pressure conditions. This capability allows the facility to more closely mimic atmospheric processes in which gases are continuously transported and replenished rather than confined in a closed system.

Impact for Exoplanet Science

CAAPSE measurements are essential for connecting theoretical atmospheric models (Fleury et al. 2023; Yang et al. 2023) with astronomical observations (*e.g.*, from the *Hubble Space Telescope* (*HST*) or the *James Webb Space Telescope* (*JWST*)). By mimicking key chemical environments in the laboratory, CAAPSE provides empirical data on photochemical pathways, reaction kinetics, and aerosol formation mechanisms in exoplanet atmospheres. The results obtained with CAAPSE help to interpret spectroscopic observations from current and future telescopes, including *JWST* and upcoming missions designed to characterize exoplanet atmospheres.



(a) FTIR spectra and (b) mass spectra from Fleury et al. (2020). (c) Optical images of organic aerosol products deposited on sapphire windows (from Fleury et al. 2019).

Recent Publications

From the Laboratory Astrophysics Community

December 2025–March 2026

Comprehensive insights into organic matter from astrophysical ice analogues by multimodal tonisation high-resolution mass spectrometry
Honold, L., Hertzog, J., Ruf, A., et al.
Monthly Notices of the Royal Astronomical Society, **547**, stag434 (2026)
https://doi.org/10.1093/mnras/stag434

Protonation-induced chemical transformations in mass spectrometry: Implications for detecting complex organics on icy moons
Hortal Sánchez, L., Napoleoni, M., Brunet, E., et al.
ACS Earth and Space Chemistry, **10**, 765 (2026)
https://doi.org/10.1021/acsearthspacechem.5c00363

Molecular inventory and comparative organic profiling of a homogenized aggregate sample from asteroid (101955) Bennu
Aponte, J. C., Buckner, D. K., Mojarro, A., et al.
Geochimica et Cosmochimica Acta, **419**, 165 (2026)
https://doi.org/10.1016/j.gca.2026.02.036

Broadband spectroscopy of astrophysical ice analogues. IV. Optical constants of N_2 ice in the terahertz and mid-infrared ranges
Kruczkiewicz, F., Gavdush, A. A., Ribeiro, F., et al.
Astronomy & Astrophysics, **707**, A344 (2026)
https://doi.org/10.1051/0004-6361/202556818

Swift heavy ion-induced chemistry of CH_3CN ices at 10 and 80 K
de Barros, A. L. F., da Costa, C. A. P., Murhej, Y., et al.
ACS Earth Space Chemistry, **10**, 850 (2026)
https://doi.org/10.1021/acsearthspacechem.5c00379

Shortwave Infrared Microimaging Spectroscopy of the Martian Meteorites
Miura, J. K., Ehlmann, B. L., Greenberger, R., Cutts, E.
Journal of Geophysical Research: Planets, **131**, e2025JE009353 (2026)
https://doi.org/10.1029/2025JE009353

Effects of particle size, temperature, and metal content on VNIR spectra of ordinary chondrite meteorites in a simulated asteroid environment
Gemma, M. E., Shirley, K. A., Glotch, T. D., et al.
Journal of Geophysical Research: Planets, **131**, e2025JE008963 (2026)
https://doi.org/10.1029/2025JE008963

Multiple formation pathways for amino acids in the early Solar System based on carbon and nitrogen isotopes in asteroid Bennu samples
Baczynski, A. A., Mcintosh, O. M., Simkus, D. N., et al.
Proceedings of the National Academy of Sciences U.S.A., **123**, e2517723123 (2026)
https://doi.org/10.1073/pnas.2517723123

Bottom-up formation of phenol (C_6H_5OH) in interstellar analog ices of acetylene and water exposed to ionizing radiation
Wang, J., Marks, J. H., Inada, S., Kaiser, R. I.
The Astrophysical Journal, **1000**, 76 (2026)
https://doi.org/10.3847/1538-4357/ae48fa

Spatially and structurally distinct IOM populations in carbonaceous chondrites describe pre-parent body thermal alteration histories and parent body aqueous alteration
Jakubek, R. S., Fries, M. D., McCubbin, F. M., et al.
Geochimica et Cosmochimica Acta, **417**, 150 (2026)
https://doi.org/10.1016/j.gca.2026.01.036

Soluble organic matter evolution during aqueous alteration in carbonaceous chondrites
Dong, M., Yang, W., Hao, J., et al.
The Innovation Geoscience, **4**, 100199 (2026)
https://doi.org/10.59717/j.xinn-geo.2026.100199

Low temperature brine formation by serpentinization on asteroid (162,173) Ryugu
Guy Libourel, Marc Portail, Vincent Guigoz, et al.
Earth and Planetary Science Letters, **679**, 119885 (2026)
https://doi.org/10.1016/j.epsl.2026.119885

Unconventional formation of cyanamide, a key intermediate in prebiotic chemical evolution, in interstellar ice analogues
Wang, J., Marks, J. H., Eckhardt, A. K., Kaiser, R. I.
The Journal of Physical Chemistry Letters, **17**, 2748 (2026)
https://doi.org/10.1021/acs.jpclett.6c00331

Chemical environment and temperature effects on the formation and destruction of C_3O_2 in cosmic-ray-processed ices
Pilling, S., Fantuzzi, F., Andrade, D. P. P., Moraes, L.
ACS Omega, **11**, 13544 (2026)
https://doi.org/10.1021/acsomega.5c11198

Compositional signatures of CM, CO, CV, and CK chondrites: Insights from Micro-FTIR spectroscopy and machine learning tools
Yesiltas, M., Glotch, T. D.
Icarus, **450**, 117009 (2026)
https://doi.org/10.1016/j.icarus.2026.117009

Abiotic sugar enantiomers in the CI carbonaceous chondrite Orgueil
Leyva, V., Robert, M., Pepino, R., et al.
Nature Communications, **17**, 2060 (2026)
https://doi.org/10.1038/s41467-026-68709-5

Astrochemistry: The building blocks of life in the universe
Das, A., Garrod, R. T.
Life Sciences in Space Research, **49**, 1 (2026)
https://doi.org/10.1016/j.lssr.2026.01.007

Laboratory investigation of simultaneous ultraviolet photoprocessing and temperature-programmed desorption of interstellar ice analogs
Sarver, C. C., Walker, C. E., Widicus Weaver, S. L.
ACS Earth and Space Chemistry, **10**, 536 (2026)
https://doi.org/10.1021/acsearthspacechem.5c00338

Pyrrole without life: Reaction of aminomethylene with the propargyl radical
McClish, R., Schleier, D., Kamer, J., et al.
The Journal of Physical Chemistry Letters, **17**, 2078 (2026)
https://doi.org/10.1021/acs.jpclett.5c03948

Formation of dimethyl sulfide (CH_3SCH_3) and ethanethiol (CH_3CH_2SH) in interstellar analog ices of methane (CH_4) and hydrogen sulfide (H_2S)
Herath, A., Turner, A. M., McAnally, M., et al.
Physical Chemistry Chemical Physics, **28**, 5094 (2026)
https://doi.org/10.1039/D5CP04456A

Influence of interstellar icy mantle composition on acetaldehyde and formamide formation induced by low-energy cosmic rays
Capuano, G. E., Urso, R. G., Fulvio, D., et al.
ACS Earth and Space Chemistry, **10**, 555 (2026)
https://doi.org/10.1021/acsearthspacechem.5c00336

Rotational spectra and interstellar search for chiral and achiral butynols and butenols: 3-Butyn-2-ol, 3-buten-2-ol, 3-butyn-1-ol, and 3-buten-1-ol
Holdren, M. S., Fried, Z. T. P., Stewart, D. A., et al.
ACS Earth and Space Chemistry, **10**, 406 (2026)
https://doi.org/10.1021/acsearthspacechem.5c00247

Millimeter-wave rotational spectroscopy and interstellar search for 2-mercaptoethanol ($HSCH_2CH_2OH$)
Bunn, H. A., Esselman, B. J., Spezzano, S., et al.
The Astrophysical Journal, **998**, 212 (2026)
https://doi.org/10.3847/1538-4357/ae2254

Radiation-driven destruction of *N*-heterocycles in the presence and absence of water ice
Tribbett, P. D., Yarnall, Y. Y., Gerakines, P. A., et al.
The Astrophysical Journal, **997**, 291 (2026)
https://doi.org/10.3847/1538-4357/ae22f0

Formation and survival of complex organic molecules in the Jovian circumplanetary disk
Mousis, O., Petetin, C., Benest Couzinou, T., et al.
The Planetary Science Journal, **7**, 41 (2026)
https://doi.org/10.3847/PSJ/ae3559

Irradiation of condensed CO reveals a new pathway for the formation of aromatic molecules in astrochemical ices
Khan, W., Ramachandran, R., Gupta, S., et al.
Life Sciences in Space Research, **49**, 94 (2026)
https://doi.org/10.1016/j.lssr.2025.09.007

Binding energy distributions of alcohols, thiols, and their precursors on interstellar water ice surfaces
Roy, A., Das, A., Sil, M., et al.
Life Sciences in Space Research, **49**, 77 (2026)
https://doi.org/10.1016/j.lssr.2025.08.005

Placing asteroid Bennu's organic solids in molecular and elemental context with those in aqueously altered carbonaceous chondrites
Cody, G. D., Alexander, C. M. O'D., Foustoukos, D. I., et al.
Geochimica et Cosmochimica Acta, **413**, 33 (2026)
https://doi.org/10.1016/j.gca.2025.09.009

Refractive indices of photochemical haze analogs for Solar System and exoplanet applications: A cross-laboratory comparative study between the PAMPRE and COSmIC experimental set-ups
Drant, T., Sciamma-O'Brien, E., Jovanovic, L., et al.
Astronomy & Astrophysics, **706**, A167 (2026)
https://doi.org/10.1051/0004-6361/202555916

Infrared spectral signatures of nucleobases in interstellar ices II: Pyrimidines
Rosa, C. A., Bergantini, A., Herczku, P., et al.
Life Sciences in Space Research, **49**, 107 (2026)
https://doi.org/10.1016/j.lssr.2025.11.005

Ion induced formation of complex organic nitrogen molecules in solid-phase adenine
Matuszewski, F., Vuitton, V., Shouse, J., et al.
Icarus, **445**, 116865 (2026)
https://doi.org/10.1016/j.icarus.2025.116865

The photochemistry of irradiated Enceladus ice analogues: Implications for the formation of ozone and carbon trioxide
Bründl, T.-M., Terwisscha van Scheltinga, J., Cazaux, S., et al.
Icarus, **444**, 116751 (2026)
https://doi.org/10.1016/j.icarus.2025.116751

^{26}Al-^{26}Mg isotope systematics of Ca-Al-rich inclusions and Al-rich chondrules in carbonaceous unequilibrated chondrite Yamato 81020
Mishra, R. K.
Meteoritics & Planetary Science, **60**, 2759 (2025)
https://doi.org/10.1111/maps.70050

Prebiotic chemistry insights for Dragonfly: Thermodynamics of amino acid synthesis in Selk Crater on Titan
Madan, I., Pearce, B. K. D.
The Planetary Science Journal, **6**, 284 (2025)
https://doi.org/10.3847/PSJ/ae1c18

CO desorption from interstellar icy grains induced by infrared excitation of super-hydrogenated polycyclic aromatic hydrocarbons
Slumstrup, L., Thrower, J. D., Hopkinson, A. T., et al.
Astronomy & Astrophysics, **704**, A74 (2025)
https://doi.org/10.1051/0004-6361/202556399

Infrared optical constants and band strengths of interstellar ice analogues: H_2O:CO_2 and H_2O:CO_2:CO mixtures at 10 K
Maté, B., Paláez, R. J., Ortigoso, J., et al.
Astronomy & Astrophysics, **704**, A56 (2025)
https://doi.org/10.1051/0004-6361/202556786

Nitrogen- and oxygen-rich organic material indicative of polymerization in pre-aqueous cryochemistry on Bennu's parent body
Sandford, S. A., Gainsforth, Z., Nuevo, M., et al.
Nature Astronomy, **9**, 1803 (2025)
https://doi.org/10.1038/s41550-025-02694-5

PISCES: Plumes and Ices Simulation chamber for Enceladus and other moonS
Bourgeois, Y. R. A., Cazaux, S. M.
Planetary and Space Science, **269**, 106206 (2025)
https://doi.org/10.1016/j.pss.2025.106206

The survival of aromatic molecules in protoplanetary disks
Piacentino, E. L., Balkanski, A., Calahan, J., et al.
The Astrophysical Journal, **994**, 155 (2025)
https://doi.org/10.3847/1538-4357/ae1134

Broadband spectroscopy of astrophysical ice analogues: III. Scattering properties and porosity of CO and CO ices
Gavdush, A. A., Ivlev, A. V., Zaytsev, K. I., et al.
Astronomy & Astrophysics, **701**, A287 (2025)
https://doi.org/10.1051/0004-6361/202556110

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Community Announcements

Upcoming Conferences, Meetings, and Workshops Relevant to Laboratory Astrophysics

Astrobiology Science Conference (AbSciCon) 2026
17–22 May 2026
Madison, WI, USA
https://www.agu.org/abscicon
Abstract submission deadline: Closed
Registration dates: 8 April 2026 (Early bird), 17 May 2026 (Regular)

18th International Conference on Quantum Chemistry (ICQC)
31 May–5 June 2026
Berkeley, CA, USA
https://www.icqc2026.org/
Abstract submission deadlines: 1 May 2026 (Posters)
Registration deadlines: 31 May 2026

The 248th AAS meeting (joint with the High Energy Astrophysics and Laboratory Astrophysics Divisions)
14–18 June 2026
Pasadena, CA, USA
https://aas.org/meetings/aas248
Abstract submission deadline: 29 May 2026
Registration deadline: 23 April 2026 (Early), 21 May (Regular), 12 June (Late)

Earth and Planetary Cloud Workshop 2026
22–24 June 2026
Pasadena, CA, USA
https://www.nasa.gov/jpl/pcarf/workshop-2026/
Abstract submission deadline: 20 April 2026
Registration deadline: 1 June 2026

International Astronomical Union (IAU) Symposium 407: Origins 2026
5–11 July 2026
Paris, France
https://originsparis.sciencesconf.org/resource/page/id/20
Abstract submission deadline: 6 April 2026
Registration dates: 9 February 2026–5 July 2026

Committee for Space Research (COSPAR) 2026 46th General Assembly
1–9 August 2026
Florence, Italy
https://cospar2026.org/
Abstract submission deadline: Closed
Registration deadlines: 17 May 2026 (Early bird), 15 July 2026 (Regular), 1 August 2026 (Onsite)

American Chemical Society (ACS) Fall Meeting 2026

Astrochemistry Subdivision Symposium: “Astrochemistry in Planetary Science”
23–27 August 2026
Chicago, IL, USA
https://www.acs.org/events/fall.html
Abstract submission deadline: Closed
Registration dates: Opens in May 2026

Europlanet Science Congress (EPSC)

6–11 September 2026
The Hague, The Netherlands
https://www.epsc2026.eu/
Abstract submission dates: To be announced
Registration dates: To be announced

European Conference on Laboratory Astrophysics (ECLA) 2026

21–26 September 2026
Heidelberg, Germany
https://www.mpia.de/ecla2026
Pre-registration available

Cosmic Rays 4: The Salt of the Star Formation Recipe

5–9 October 2026
Pisa, Italy
https://sites.google.com/view/cosmic-rays-4/
Abstract submission deadline: 28 June 2026
Registration dates: July 2026–15 September 2026

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