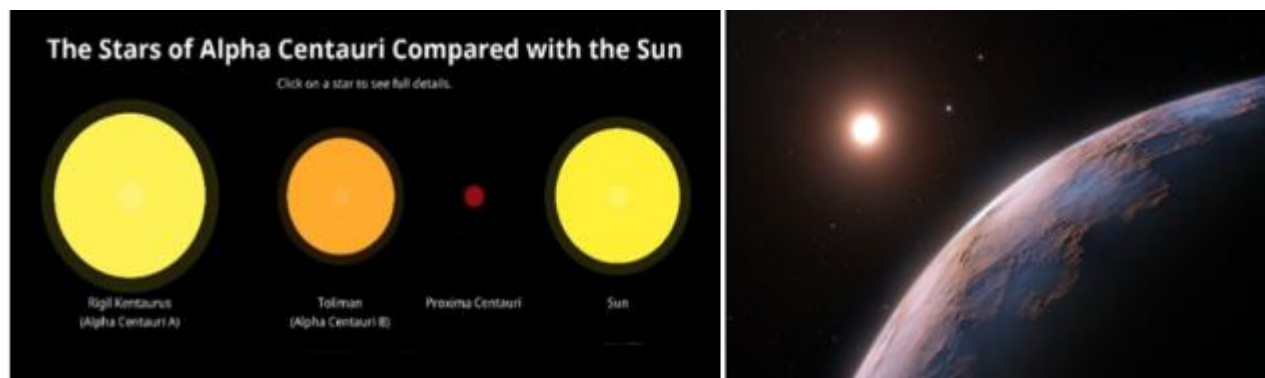


Worlds Beyond and Astrobiology Insights - Blog #16

Proxima Centauri d: A New World in Our Closest Star System

Christopher S. Centi September 28, 2025



On the left is a size comparison of Alpha Centauri A & B, Proxima Centauri and the Sun. On the right is an artist's impression showing a close-up view of Proxima d, a planet candidate recently found orbiting the red dwarf star Proxima Centauri, the closest star to the Solar System. The planet is believed to be rocky and to have a mass about a quarter that of Earth. Two other planets known to orbit Proxima Centauri are visible in the image too: Proxima b, a planet with about the same mass as Earth that orbits the star every 11 days and is within the habitable zone, and candidate Proxima c, which is on a longer five-year orbit around the star. Credit: ESO/L. Calçada. On the left is a size comparison of Alpha Centauri A & B, Proxima Centauri and the Sun.

Introduction: A Planet Next Door

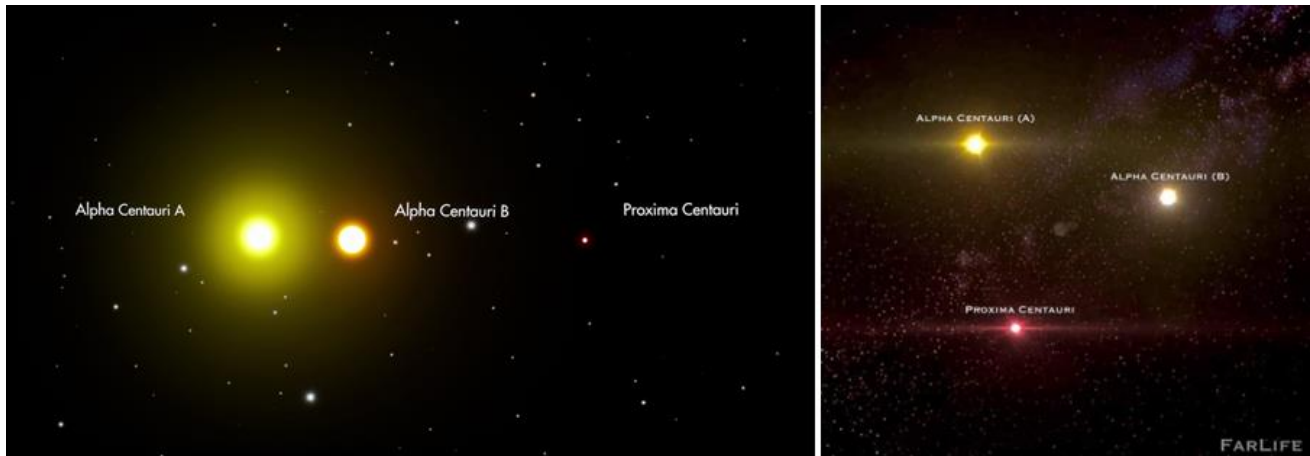
In July 2025, astronomers confirmed the existence of a third planet orbiting Proxima Centauri -- the closest star to our Sun. This new world, Proxima Centauri d, is a small, rocky planet that joins its siblings Proxima b and Proxima c in the Alpha Centauri system, located just 4.2 light-years away. Though it's far beyond the reach of current spacecraft, it's tantalizingly close in cosmic terms -- our nearest planetary neighbor outside the solar system.

What makes Proxima d remarkable isn't its habitability -- it's likely far too hot for life as we know it, but its size and detection method. At just 0.26 times the mass of Earth, it's the least massive exoplanet ever discovered using the radial velocity method, a technique that detects the subtle "wobble" of a star caused by an orbiting planet's gravitational pull. This achievement pushes the boundaries of what our instruments can detect and opens new doors for studying small, rocky worlds around other stars.

Proxima d's discovery also adds a new piece to the puzzle of planetary architecture in the Alpha Centauri system. With three known planets orbiting a red dwarf star, scientists can begin to compare how planetary systems form and evolve in different stellar environments. It's a chance to ask: How common are rocky planets? What conditions shape their atmosphere, climates, and potential for life?

For scientists, educators and dreamers alike, Proxima Centauri d is more than a data point -- it's a symbol of possibility. It reminds us that the universe still holds surprises, even in the star system next door. Whether you're charting its orbit, sketching its surface, or imagining life beneath its crust, Proxima d invites us to explore, to question and to wonder.

The Alpha Centauri System: A Triple-Star Neighborhood



The Alpha Centauri system is our closest stellar neighbor -- a gravitationally bound trio of stars located just 4.2 light-years from Earth. Though it may appear as a single point of light in the southern sky, this system is a dynamic and complex arrangement of three very different stars:

Alpha Centauri A & B

These two stars are Sun-like in size and brightness, orbiting each other in a tight binary system. Their mutual orbit takes about 80 Earth years to complete, and they're separated by a distance roughly equivalent to the span between Uranus and the Sun. Because of their similarity to our Sun, Alpha Centauri A and B have long been considered promising candidates in the search for Earth-like planets, but so far, no confirmed planets have been found around them.

Proxima Centauri

Orbiting far beyond the A - B pair is Proxima Centauri, a cool red dwarf that's much smaller and dimmer than the Sun. Despite its faint glow, Proxima is the closest star to Earth, making it a prime target for exoplanet research and future interstellar missions. Its distance from Alpha Centauri A and B is vast -- over 13,000 AU -- but gravitationally, it's still part of the system.

Proxima Centauri is one of the three stars confirmed to host planets. So far, astronomers have discovered:

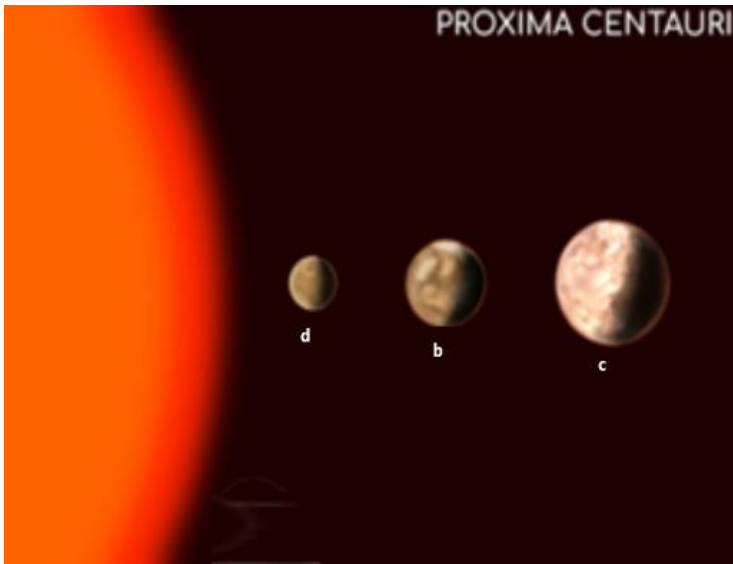
- Proxima b: A potentially habitable, Earth-sized planet in the star's temperate zone
- Proxima c: A larger, colder planet orbiting farther out
- Proxima d: A tiny, hot terrestrial planet orbiting extremely close to the star

These discoveries make Proxima Centauri a planetary laboratory just beyond our solar system, a place where scientists can study how planets form and survive around small, active stars.

Why It Matters

- The Alpha Centauri system is a top candidate for future interstellar probes, including concepts like Breakthrough Starshot, which aims to send ultra-fast spacecraft to Proxima Centauri within a human lifetime.
- Studying this system helps scientists understand how planetary systems vary across different types of stars, especially in multi-star environments.
- For educators and students, it's a gateway to exploring stellar dynamics, planet formation and the possibility of life beyond Earth -- all within our cosmic backyard.

Meet Proxima Centauri d



A Tiny World with Big Scientific Value

Discovered in **July 2025**, **Proxima Centauri d** is the third confirmed planet orbiting **Proxima Centauri**, our closest stellar neighbor. Though it's far too hot to be considered habitable by Earth standards, this **sub-Earth-sized** planet offers a rare opportunity to study the architecture of a nearby planetary system and to push the limits of exoplanet detection.

Key Characteristics

Attribute	Value
Mass	~0.26 Earth masses
Radius (estimated)	~0.81 Earth radii
Orbital Period	5.1 Earth days
Orbital Distance	0.02881 AU ($\approx$ 4.3 million km)
Temperature Estimate	~360 K (87 °C / 188 °F)
Discovery Method	Radial velocity
Discovery Date	July 2025

Environment & Orbit

Proxima d orbits **extremely close** to its host star -- just **0.02881 AU**, which is less than 1/30th the distance between Earth and the Sun. This proximity means it completes a full orbit in just **5.1 Earth days**, racing around its star at high speed. It also receives nearly **twice the solar radiation** Earth does, resulting in a surface temperature of around **360 K** -- hot enough to challenge most known forms of life.

Because of its tight orbit, Proxima d is likely **tidally locked**, meaning one hemisphere is in constant daylight while the other remains in perpetual darkness. This creates extreme temperature contrasts and raises questions about atmospheric circulation, heat transfer and potential microhabitats.

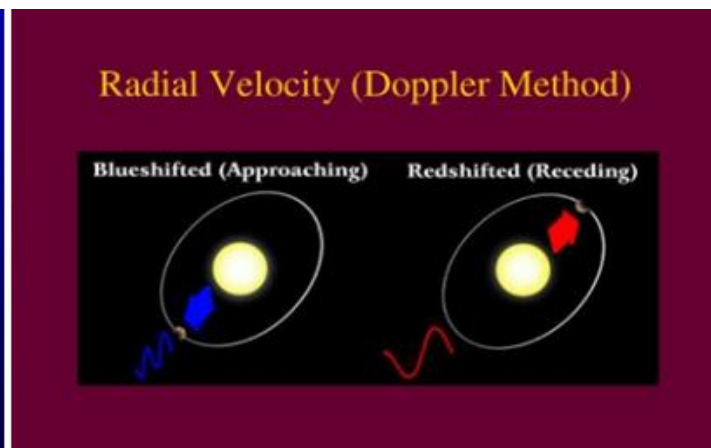
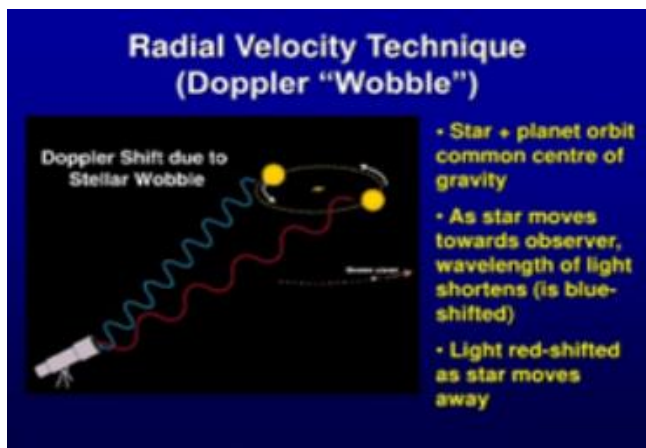
Habitability Hints?

Despite its harsh surface conditions, some **climate models** suggest that **polar regions** or the **twilight zone** (the terminator line between day and night) could maintain **moderate temperatures**, especially if the planet has a thin but stable atmosphere. These regions might offer refuge for hypothetical life forms -- or at least be targets for future robotic exploration.

Why It Matters

- **Smallest exoplanet** ever detected via the **radial velocity method**, showcasing the precision of modern instruments.
- Adds to our understanding of **planetary systems around red dwarfs**, which are the most common stars in the galaxy.
- Offers a nearby test case for studying **tidal locking**, **stellar radiation**, and **atmospheric retention**.
- Serves as a stepping stone for future missions, such as **Breakthrough Starshot**, which aims to send ultra-fast probes to Proxima Centauri.

How Was It Discovered?



The radial velocity method to detect exoplanets is based on the detection of variations in the velocity of the central star, due to the changing direction of the gravitational pull from an (unseen) exoplanet as it orbits the star. When the star moves towards us, its spectrum is blueshifted, while it is redshifted when it moves away from us. By regularly looking at the spectrum of a star - and so, measure its velocity - one can see if it moves periodically due to the influence of a companion. Credit ESO

Detecting a Tiny World Through Stellar Wobbles

Proxima Centauri d wasn't spotted through a telescope. It was **inferred** from the subtle dance of its host star. Like many exoplanets, it was discovered using the **radial velocity method**, a technique that detects the tiny back-and-forth motion of a star caused by the gravitational tug of an orbiting planet.

What Is Radial Velocity?

Stars don't sit perfectly still. When a planet orbits a star, it pulls on the star ever so slightly, causing it to **wobble**. This wobble shifts the star's light:

- **Toward us** = blue shift
- **Away from us** = red shift

By measuring these shifts in the star's spectrum over time, astronomers can detect the presence of a planet -- even if they can't see it directly.

The Journey to Confirmation

- **2020:** A faint signal was first noticed in data from the **ESPRESSO spectrograph**, a high-precision instrument mounted on the **Very Large Telescope (VLT)** in Chile.
- The signal hinted at a small planet orbiting very close to Proxima Centauri, but it was **too weak** to confirm.
- **2020–2025:** Astronomers continued collecting data, refining their models and filtering out noise from stellar activity.
- **July 2025:** With enough high-quality observations, the team confirmed the existence of **Proxima Centauri d** -- the **smallest exoplanet ever detected** using radial velocity.

Why This Matters

- Detecting such a **low-mass planet** (just 0.26 Earth masses) is a major technical achievement.
- It showcases the power of **precision spectroscopy** and long-term observation.
- It adds a new piece to the puzzle of the **Alpha Centauri planetary system**, helping scientists understand how small, rocky worlds form around red dwarfs.

Why Proxima d Matters

A Tiny Planet with Outsized Impact

Though **Proxima Centauri d** is unlikely to host life, its discovery marks a major milestone in exoplanet science. This small, rocky world -- just **0.26 times the mass of Earth** -- was detected using the **radial velocity method**, a technique that measures the subtle gravitational tug a planet exerts on its star. Detecting such a low-mass planet pushes the boundaries of current technology and opens new doors for exploring nearby planetary systems.

Scientific Significance

- **Planetary Formation Around Red Dwarfs**
Red dwarfs are the most common stars in the Milky Way, yet their planetary systems are still poorly understood. Proxima d adds a crucial datapoint, helping scientists refine models of how rocky planets form and survive in these volatile environments.
- **Instrument Sensitivity**
The detection of Proxima d showcases the precision of instruments like **ESPRESSO** at the **Very Large Telescope (VLT)**. It proves that even **sub-Earth-sized planets** -- smaller than Mars -- are now within observational reach.
- **Mission Planning & System Modeling**
Understanding the layout of the **Proxima Centauri system** helps scientists design future interstellar probes. Knowing where planets are, how they orbit and what conditions they face is essential for targeting biosignature searches and landing site selection.

“Proxima d is a technical triumph,” said Dr. Pedro Faria, one of the lead researchers. “It shows we’re entering an era where even sub-Earths are within reach.”

Habitability: A Cautionary Tale

A Harsh World with Hidden Possibilities

Proxima Centauri d orbits just **0.02881 AU** from its host star -- less than 5% of Earth’s distance from the Sun. This extreme proximity exposes it to intense **stellar radiation**, including frequent **solar flares**. Red dwarfs like Proxima Centauri are known for their volatility and such flares can strip away planetary atmospheres, sterilize surfaces and disrupt climate stability.

Environmental Challenges

- **Tidal Locking**

One side of the planet likely faces the star permanently, baking under constant light, while the other remains in darkness. This creates extreme temperature gradients and complicates atmospheric circulation.

- **Atmospheric Loss**

Without a strong magnetic field or thick atmosphere, Proxima d may be vulnerable to **atmospheric erosion**, leaving its surface exposed to harsh space conditions.



Artist's concept of a stellar flare from Proxima Centauri. Credit: NSF/AUI/NSFN

Emerging Questions

Despite these challenges, Proxima d invites bold scientific speculation:

- **Could subsurface life exist in shielded environments?**

Life might survive beneath the surface, protected from radiation and temperature extremes -- similar to microbes found in Earth's deep crust or Antarctic ice.

- **Might future missions detect biosignatures in polar regions?**

If Proxima d retains any atmosphere, its poles or twilight zones could host stable conditions where chemical traces of life might accumulate.

- **What does this mean for the habitability of Proxima b and c?**

Proxima b lies in the star's temperate zone and remains a top candidate for habitability. Understanding Proxima d's environment helps scientists refine expectations for its siblings and for red dwarf planets across the galaxy.

Implications for Interstellar Exploration

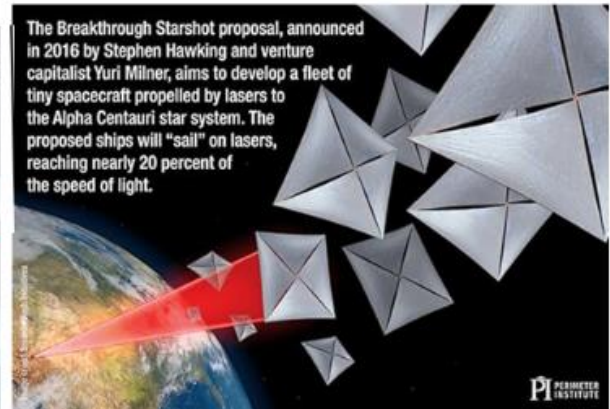
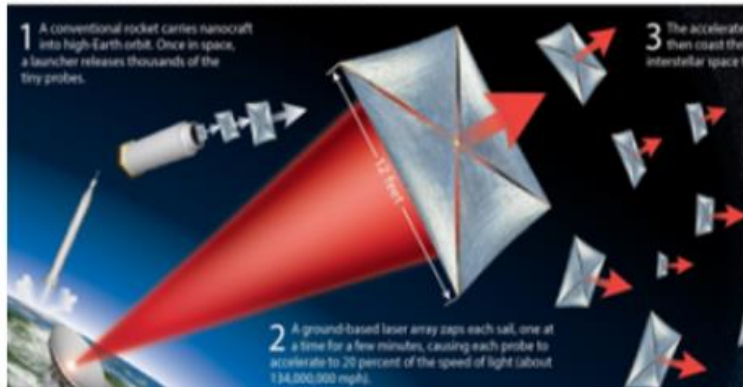
Proxima Centauri d: A New Target in Our Cosmic Neighborhood

The discovery of **Proxima Centauri d** adds a new layer of complexity and opportunity to humanity's long-term vision of interstellar exploration. As the closest star system to Earth, **Alpha Centauri** has long been a focal point for mission planning. Now, with three confirmed planets orbiting **Proxima Centauri**, including the potentially habitable **Proxima b**, the stakes for exploration are higher than ever.

Breakthrough Starshot & Beyond

- **Breakthrough Starshot** is a proposed mission to send **laser-propelled nanoprobes** to Proxima Centauri at **20% the speed of light**, reaching the system in just over **20 years**.
- These probes would carry cameras, sensors and communication systems, offering humanity its first close-up look at an exoplanetary system.

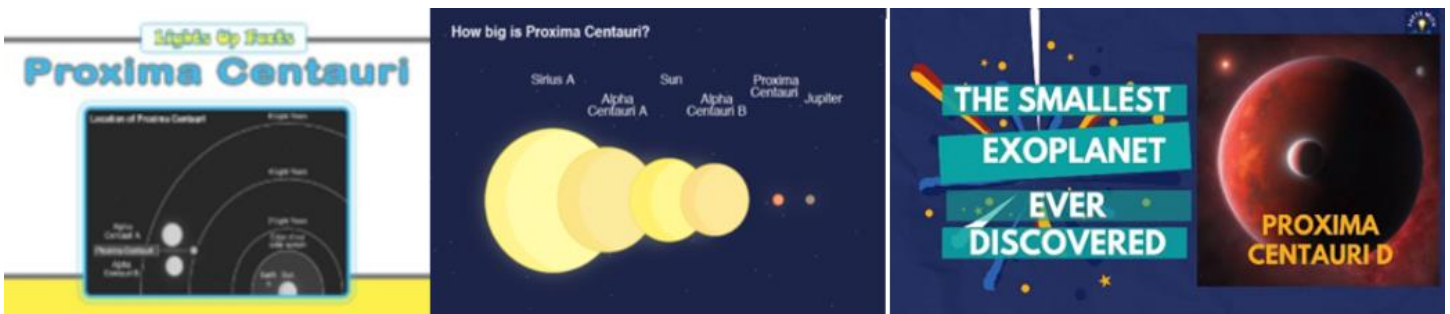
HOW TO REACH INTERSTELLAR SPACE



Why Proxima d Matters

- **Gravitational Dynamics:** Proxima d's presence affects the overall gravitational field of the system, which could influence **spacecraft trajectory planning**, orbital insertion, and flyby timing.
- **New Imaging Target:** Future space telescopes like **LUVOR** (Large UV Optical Infrared Surveyor) and **HabEx** (Habitable Exoplanet Observatory) may be able to **directly image** Proxima d, revealing surface features, atmospheric composition and thermal profiles.
- **Comparative Planetology:** Studying Proxima d alongside b and c allows scientists to explore how planetary environments vary within the same system -- especially around volatile red dwarf stars.

Outreach Angle: Bringing Proxima d to the Classroom



From Discovery to Design: A Hands-On STEM Opportunity

For educators and science communicators, **Proxima Centauri d** is a golden opportunity to connect students with cutting-edge astronomy, planetary science and engineering design. It's a chance to turn distant data into tangible learning.

Classroom Integration Ideas

The following are just some of the ways learning about Proxima d and exoplanets can be incorporated into the classroom.

1. Exoplanet Detection Lab

- Simulate the **radial velocity method** using styrofoam balls, skewers or turntables to model stellar wobble.
- Use online tools like [NASA's Eyes on Exoplanets](#) to explore real data.

2. Planetary Comparison Chart

- Compare Proxima d with Earth, Mars and Proxima b using mass, radius, temperature and orbit.
- Discuss what makes a planet habitable -- and why Proxima d falls short.

3. Tidal Locking & Radiation Simulation

- Use heat lamps and rotating spheres to model tidal locking and temperature gradients.
- Explore how stellar flares from red dwarfs affect planetary atmospheres and surface conditions.

4. Mission Design Challenge

- Students “design” a robotic probe to visit Proxima d:
 - Choose instruments (spectrometer, radiation shield, thermal camera)
 - Factor in orbit, temperature and radiation exposure
 - Sketch spacecraft, write mission goals and present to the class

5. Ethics & Exploration Debate

- Should we send probes to potentially lifeless but fragile worlds?
- What responsibilities do we have when exploring other systems?

Why It Works

- Supports **NGSS**, **Common Core**, and **C3 Framework** standards
- Encourages **critical thinking**, **collaboration**, and **creativity**
- Bridges **science and storytelling**, making space exploration personal and inspiring

For a complete lesson based on this blog click on the following link: [Exploring Proxima Centauri d Lesson](#)

Final Reflections: A Small Planet, A Big Signal

Proxima Centauri d isn't just a discovery -- it's a declaration.

This tiny world, orbiting the faint glow of our nearest stellar neighbor, may never host life or welcome explorers. Its surface is likely scorched, its atmosphere uncertain and its orbit precariously close to a volatile red dwarf. But its existence sends a clear and thrilling message: **we are entering a new era of planetary discovery** -- one where even the smallest, most elusive worlds are within reach.

Just a generation ago, detecting a planet smaller than Mars around a star 4.2 light-years away would have seemed impossible. Today, thanks to instruments like **ESPRESSO** and the ingenuity of global teams, we've not only found it -- we've begun to understand it. Proxima Centauri d is a testament to human curiosity, technological precision and the relentless pursuit of knowledge.

It's not a second Earth. It's not a place we'll colonize or terraform. But it is a **new chapter in our cosmic story** -- a reminder that the universe is not just vast, but **rich with structure, diversity and surprise**. Every new planet we discover reshapes our understanding of what's possible and where we might go next.

For students, it's a call to imagine. For scientists, it's a challenge to refine. For educators and communicators, it's a chance to connect the dots between data and dreams. And for all of us, it's a sign, quiet but profound that the stars still have secrets to share.

As we build better telescopes, launch faster probes and train sharper minds, we move closer to answering the questions that have echoed across generations:

Are we alone? What lies beyond? And how far can we go?

Proxima Centauri d may be small, but its signal is loud:

The search is working. The story is unfolding. And the universe is listening.

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