

When Solar Particles Kiss Venus: A Future Scientist's Cosmic Guide

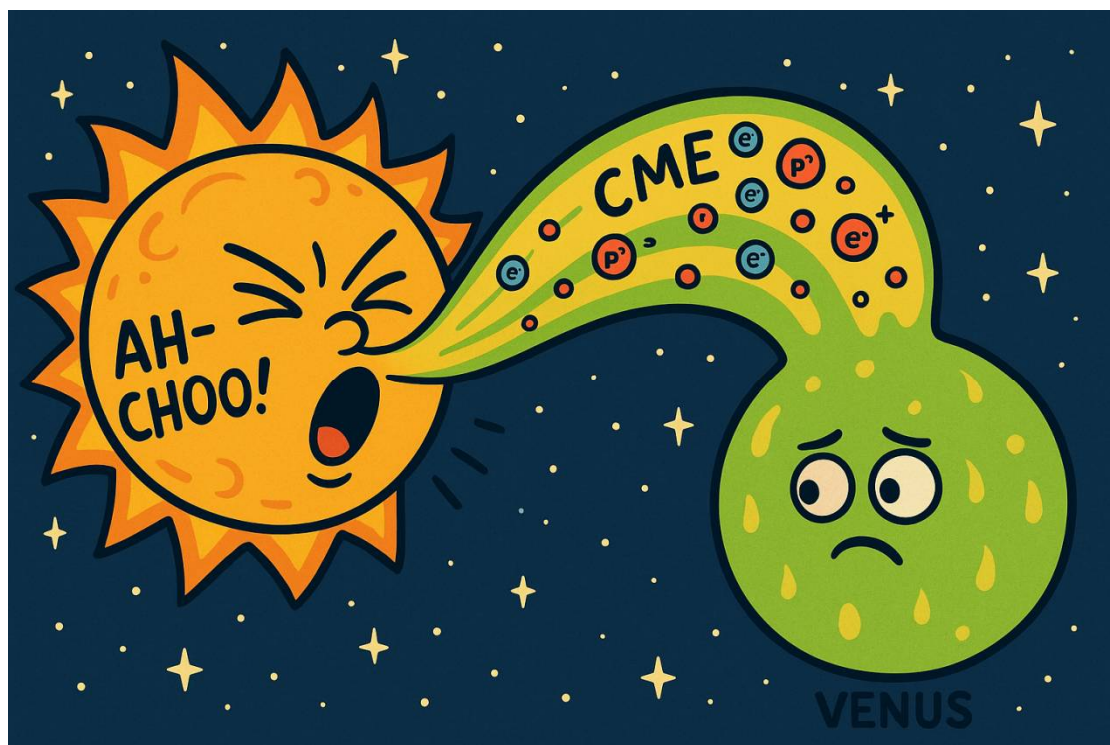
Dear Pucheng,

Hello from a decade ahead! I'm writing to you from a parallel timeline where I've just embarked on my master's studies in Earth and Planetary Science at the University of Tokyo, one of Asia's most prestigious research institutions. First and foremost, congratulations! I'm so proud that you never abandoned the dreams you held as a kid and that your passion and curiosity have carried you all the way here. You've always envisioned a future filled with discovery, and you've always wanted to become a scientist. I'm delighted to tell you that you're well on your way to making that dream a reality.

Do you remember the nights you spent propped up on our rooftop, telescope in hand, tracing the constellations and marveling at the Milky Way? Those long, quiet hours fueled your fascination with the cosmos, and now I delve into the very phenomena that once captivated you from afar. My research centers on the physics and chemistry shaping other worlds—how solar particles interact with planetary atmospheres, how magnetic and electric fields dance across planetary surfaces, and how these processes reveal themselves in breathtaking displays of light. In particular, I study the aurorae on Venus: what triggers them, how they evolve, what structures they form, and what secrets they hold about each planet's atmosphere and magnetic environment.

Here's a glimpse into the science we explore. When high energy particles emitted by the Sun—known as Solar Energetic Particles, or SEPs—slam into Venus's thick, carbon dioxide-dominated atmosphere, they collide with oxygen and carbon dioxide, excite them, and produce faint green glows. Those SEPs arrive in two main types: Corotating Interaction Regions (CIRs), which occur when fast solar wind streams overtake slower ones, and Coronal Mass Ejections (CMEs), massive bursts of plasma and magnetic fields expelled by the Sun—like the star's little "sneezes." On Earth, our global

magnetic field funnels these particles toward the poles, painting the Arctic and Antarctic skies with dazzling ribbons of light. Venus, however, lacks an magnetic shield, so its entire nightside can shimmer with diffuse auroral glows—though much dimmer and less structured than our own polar lights. Scientists used ground-based telescopes to detect green aurora on Venus for the first time, but they did not provide a detailed explanation of how this phenomenon occurs. We were the first to use simulation method to simulate the process by which SEPs generate the aurora, and our results matched the actual observations very well, successfully explaining the origin of this phenomenon!



Looking back to our undergraduate years, you had a rare freedom to explore any discipline: mathematics, classical physics, organic chemistry, computer science, biology—and, of course, planetary science. You spoke with professors across departments and attended countless seminars. While you appreciated the elegance of pure math and the rigor of theoretical physics, your heart gravitated toward tangible, hands on investigations—especially those that touched the mysteries of space. That calling led you to enroll in my current field. I still recall the day in 2020 when China’s

first Mars mission, Tianwen 1, launched. The thrill you felt when the Zhurong rover's first Martian selfie streamed back to Earth lit a fire in your soul: this was our nation's grand entry into deep space exploration, and you knew you had to be part of it.

Even more exciting are the missions on the horizon. JAXA and ESA's Martian Moons eXploration (MMX) mission will approach Phobos, gather surface samples, and return them to Earth. ESA's EnVision spacecraft will map Venus's surface and atmosphere with unprecedented precision, unveiling the planet's volcanic history and atmospheric dynamics. Meanwhile, back home, the Tianwen 2 and Tianwen 3 missions will collect and return samples from the near Earth asteroid 2016HO3 and, eventually, from the Martian surface itself. Each mission promises to expand our understanding of planetary formation, atmospheric evolution, and the conditions that might support life beyond Earth. Planetary science remains a vast, uncharted ocean of possibilities—our curiosity about life's origins, the hunt for extraterrestrial organisms, and the search for new habitable worlds drives us to explore these alien laboratories.

Of course, the path has not been without its challenges. You've always been introverted, preferring to wrestle with tough problems alone rather than ask for help. That independent streak served you well at times, but it also cost you valuable time and energy as you reinvented the wheel through endless trial and error. Once, you taught yourself how to use a new tool, and it took you almost a month just to barely understand what it was. In fact, it was already a very mature tool, and quite a few of your friends around you knew how to use it well. If you had sought their guidance and help, I think you could have learned how to use it much more quickly. Here's something I wish someone had told you sooner: asking questions is the cornerstone of scientific progress, not a sign of weakness. Whether you seek clarity on a fundamental concept or propose a bold, out of the box hypothesis, each question you ask in the lab or classroom could spark a breakthrough. Moreover, embrace collaboration—talk with peers and mentors from diverse disciplines. Fresh perspectives often reveal overlooked details, guide you around pitfalls, and open

doors to entirely new research directions.

Above all, never stop thinking. Cultivate a boundless curiosity, even in subjects that feel challenging—chemistry, biology, computational modeling. The most profound scientific insights often emerge at the intersections of fields, where methods and knowledge from one discipline shed new light on another. Stay flexible in your approach, patient in mastering new techniques, and fearless in pursuing questions that others deem “too hard” or “too speculative.” It’s precisely those questions that, when answered, illuminate the deepest mysteries of our universe.

As you continue this journey, remember that every setback is a learning opportunity, and every surprise is an invitation to explore further. Keep a journal of your ideas, no matter how half formed they may seem—future experiments and collaborations can breathe life into even the wildest notions. Seek out conferences, workshops, and informal gatherings; the most occasional connections often happen over coffee and lunchtime chats. And while rigorous methodology is essential, never lose sight of the joy that first inspired you—the wonder of gazing up at the night sky and imagining worlds beyond our own.

So, Pucheng, keep dreaming. Keep questioning. Keep looking up. The universe is vast, and it’s waiting for you to uncover its secrets. You’re already farther along than you realize, and the best discoveries lie just beyond the horizon of what we know today.

Best Regards,

Your Future Self

Acknowledgement: This article was polished using GPT-4o and includes images generated by it.