Researchers cook up distant bodies' atmospheres 'in a bottle' at Hopkins lab

Sarah Horst, an assistant professor of planetary sciences at Johns Hopkins University, talks about some of her lab's work on simulating other planets's atmospheres here on earth. (Lloyd Fox / Baltimore Sun)

By **Scott Dance**
The Baltimore Sun

MAY 19, 2017, 6:29 AM

If Sarah Hörst could travel to Saturn's largest moon to study its atmosphere, she would. Instead, she brought Titan's gases and dust to her Johns Hopkins University lab.

In a metal canister about the size of a shoe box, Hörst and her team of graduate student researchers created "an atmosphere in a bottle." A series of tubes pump in gases like those they believe might be found on a distant body, heat them or cool them to the proper temperature and zap them with an electric charge that acts like a burst of charged particles from a star like the sun.

The results, after a series of chemical reactions too complex for them to reliably predict on paper, can be an entirely new combination of gases, production of tiny solid particles suspended in a haze, or even some oxygen and water.

The experiments already have helped them better understand what's happening on Titan and Pluto, for example. Next, they could offer lessons about worlds that haven't yet been discovered — and that could host life.

"We're interested in how atmospheric chemistry affects the habitability of a planet," Hörst said.

She is helping other planetary scientists prepare for future discoveries by showing them what conditions they might encounter in the atmospheres of distant bodies.

When telescopes give astronomers a glimpse of Earth-like planets like the system revealed around the star TRAPPIST-1 in February, they don't have any way to detect life itself, for instance, or to precisely quantify different substances they detect.

Hörst's lab could help astronomers reverse-engineer their findings based on what experiments have demonstrated in her lab.

"We're really excited to help them understand the data they're getting," she said.

The lab was built out three years ago, and, so far, has largely been dedicated to the study of atmospheres within the solar system.

In each experiment, Hörst's graduate students fill the cylindrical metal chamber with a prescribed recipe of gases and heat it up or chill it with liquid nitrogen, depending on the temperature of the planet or moon they're recreating. Some experiments are as hot as 500 to 700 degrees Kelvin, or 440 to 800 degrees Fahrenheit.

Then, they send an electrical charge down copper wiring in the center of the tube to simulate the barrage of energy the atmosphere might get from lightning or from charged particles like the solar wind. Depending on the types of gases being used, the chamber glows in brilliant blue or purple.

After three days of continuously charging the chamber, the researchers measure how the gas composition has changed and how much of the tiny particles known as tholins have accumulated. They examine the dust left behind on small quartz disks, measuring the size of each particle and how they interact with light.

Titan is the body Hörst has considered her research focus — her Twitter profile, which has nearly 26,000 followers, describes her as a "Titan evangelist."

A paper she wrote about the moon of Saturn published in the Journal of Geophysics Research in March combined her lab experiments with data from remote sensing, spacecraft measurements and models to describe Titan's substantial nitrogen-based atmosphere.

Titan is home to "atmospheric chemistry that far surpasses any other solar system atmosphere, and [is] the only other solar system body with stable liquid currently on its surface," she wrote.

The lab's experiments have turned now to more distant worlds that could have atmospheres that are similarly interesting — or entirely different.

Astronomers have been discovering a growing number of planets outside the solar system, known as exoplanets, and they're expected to find more once the James Webb Space Telescope begins exploring in 2019. The telescope, which will be managed and operated from the Space Telescope Science Institute in Baltimore, is better equipped than any other observatory to survey for and study exoplanets.

But the discoveries to date are limited. For example, when scientists found seven Earth-sized planets orbiting TRAPPIST-1 about 39 light years from the solar system, all they knew was that the planets are within what is considered a "habitable zone" in which temperatures are moderate enough for life to exist. Researchers don't know if the planets have substantial atmospheres but plan to explore whether they do, and if so, what elements they contain.

Even when they collect more data, though, the scientists might not understand exactly what they're looking at on the distant planets.

"A lot of them won't behave like planets in our solar system," Hörst said.

Hörst's lab's exoplanet experiments will provide at least a starting point for scientists' expectations. Distant atmospheres are usually studied by watching their planet or moon pass in front of a star, so understanding the characteristics of hazes and how they interact with light could help astronomers reach conclusions that might otherwise require a lengthy and expensive space mission.

Earth's atmosphere protects the planet's residents from deadly radiation and maintains livable temperatures, while also providing air to breathe, for example. Other bodies that have been studied, like Venus or Titan, have complex atmospheres yet are unfit for life.

The research is necessary because atmospheric chemistry is too complex to predict using formulas, said Nikole Lewis, who is eager to apply Hörst's research to her work as an astronomer at the space telescope institute. Lewis joked she has "commandeered" Hörst's lab to simulate the chaos of chemical reactions she hopes to spy using Webb.

"You get to a point where you can't actually use math to figure out what's going on; you have to do work in the lab, and that's why Sarah's work is so important," Lewis said. "By making these things in the lab, we can see how we'd expect that to affect the light coming from these exoplanets."

Hörst's lab isn't the first to do this sort of research. The famous astronomer Carl Sagan pioneered it at Cornell University, making revelations about the atmospheres of Venus and Jupiter.

"It's kind of fun to carry that legacy," she said.

sdance@baltsun.com

twitter.com/ssdance

This article is related to: Scientific Research, Space, Astronomy and Astrophysics, Cornell University