Planets Pass Gas, Too!

Planets are much smaller than stars and therefore have less atmosphere to blow out as winds. As a result, the winds produced by most planets are so small that they would be very hard to measure. That's why many scientists were so intrigued by a new study led by astronomer Jessica Spake at the University of Exeter in the UK reports the discovery of a wind of helium from a rather fluffy planet known as WASP-107b. Why "fluffy"? Well, this planet is about the same size as Jupiter (so, it's really big), but has a mass only one tenth as large (so it doesn't have much mass). Recall that density is mass/volume, so if you do the calculation, WASP-107bt has a very low density— about 100 times less than a typical feather pillow!

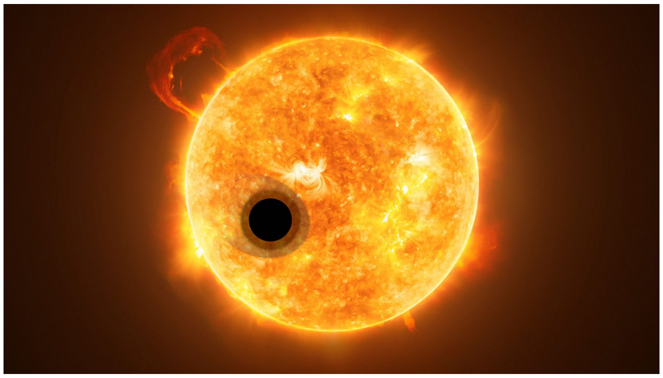

Figure 1. Artist's Rendition of WASP-107b. In this artist's rendition of WASP-107b, the planetary winds leaving the planet can be seen as well as the stellar winds leaving the star WASP-107b is orbiting. Credit: [ESA/Hubble, NASA, M. Kornmesser]

WASP-107b's fluffiness has a few interesting consequences. For one, the gravitational force pulling on the atoms and molecules of gas in the planet's upper atmosphere is quite weak. This should make sense since it has an extremely large radius compared to other planets with a similar mass. Its low gravitational force becomes even more interesting when you also consider another characteristic of the planet: its temperature. WASP-107b is 20 times closer to its star than Earth is to the sun, which means that it receives intense solar radiation, far more than you would sitting outside on even the sunniest day here on Earth. The authors estimate the planet's lower atmosphere has temperatures greater than 650 Kelvin (or more than 700°F)! But how do these characteristics affect its planetary winds? To understand,scientists have to consider two important physics concepts: escape velocity and kinetic energy of particles.

First, escape velocity: Consider what would happen if you picked up a toy rocket and threw it upward with all your might. No matter how strong you are, it would probably travel a handful of meters and fall back to the ground under the force of Earth's gravity. Now consider fueling that rocket with a chemical reaction that will continue propelling it upward, increasing its velocity after it leaves the ground. If there is enough fuel, it will eventually go so fast that it will overcome Earth's gravity and go out into space. We call the critical speed needed to overcome a planet's gravitation the **escape velocity**.

Second, the kinetic energy of particles: Consider what happens to the particles of water vapor leaving a boiling hot pot of water. The atoms and molecules in this hot vapor are moving at remarkably fast average velocities. After all, the temperature of a gas is really just a measure of the average kinetic energy of the particles in that gas.

Now consider these two principles applied to the planet WASP-107b. Because of the intense solar radiation, some of the particles in its atmosphere will be moving at very high velocities. Because the planet's gravitational force is weak, its escape velocity is fairly low. Fast-moving particles + low escape velocity = lots of particles escaping! This escape is what causes the planetary wind.

What would the planetary wind from WASP-107b be made of? Since Earth and most other planets in our solar system don't have strong planetary winds, we don't have a lot of examples to look at. But based on the physics principles we considered above, we can predict the result. If kinetic energy is constant, the speed of a particle will be higher if its mass is lower, so the very lightest elements in the planet's atmosphere will have the highest average speeds. That means that the planetary wind will be disproportionately made of light elements such as helium.

So what does this mean for our own planet, and how life could come to form on a planet like Earth? Work in this field aims to uncover how the atmospheres of planets form and change over time. While much of the work being done today focuses on billowy, close-in planets like WASP-107b, newer and bigger telescopes in development now will help us observe the atmospheres of smaller exoplanets. Eventually, astronomers may be able to make detailed measurements of atmospheres on planets that look a lot more like Earth.

Reference

Spake, J., Sing, D., Evans, T., Oklopčić, A., Bourrier, V., Kreidberg, L., Rackham, B., Irwin, J., Ehrenreich, D., Wyttenbach, A., Wakeford, H., Zhou, Y., Chubb, K., Nikolov, N., Goyal, J., Henry, G., Williamson, M., Blumenthal, S., Anderson, D., Hellier, C., Charbonneau, D., Udry, S. and Madhusudhan, N. (2018). Helium in the eroding atmosphere of an exoplanet. *Nature*. 557(7703): 68–70.

BiteScientist Profiles

Nathan Sanders is an astrophysicist and statistician working in industry. His astronomical research focused on core-collapse supernovae, the explosive deaths of the most massive stars in the universe. Like the science in this bite, those explosions rely on laws of physics at scales unlike anything we experience day to day on Earth. In his free time, Nathan enjoys hiking, gardening, and analyzing volumetric flow data from municipal combined sewer systems.

Kristen L. Cacciatore is a full-time chemistry and physics teacher at Charlestown High School, an urban public school. Kristen, who has a doctorate in green chemistry, has led a high school-elementary school science mentoring program and the Advanced Placement science enrichment and support program for the Boston Public Schools. She also serves as a mentor for beginning and pre-service teachers. In her free time Kristen likes to run, cook and travel the world.