Atmospheric Beacons Guide NASA Scientists in Search for Life

New heliophysics research proposes a novel approach to sniffing out exoplanet atmospheres. It takes advantage of frequent stellar storms — which hurl huge clouds of stellar material and radiation into space — from cool, young dwarf stars to highlight signs of habitability. In addition to searching for byproducts from life as we know it such as oxygen, methane or carbon dioxide, the Nature Scientific Reports study published on Nov. 2, 2017, suggests hunting for cruder signatures that can reveal the presence of fundamental prerequisites to life and have strong infrared emitting power -- which can therefore be easier to detect with current resources.

Stars like our Sun are turbulent in their adolescence, frequently producing powerful storms that fling stellar particles to near-light speeds. Unlike our Sun, cooler stars may continue to produce strong storms for billions of years, exposing an exoplanet to a long-term particle onslaught. When the high-energy particles reach an exoplanet, they break molecular nitrogen and oxygen – key prerequisites for life as we know it -- down into compounds that can be more easily detected. Detecting such signatures would point to the existence of the original crucial atmospheric gases.

Such signatures can form in planetary atmospheres under the onslaught of stellar storms, which generate swarms of high-energy particles. If these energetic particles collide with molecular nitrogen and oxygen in an exoplanet atmosphere, they break the gases down into individual atoms. Similarly, they break water molecules down into hydroxyl. From there, the reactive nitrogen and oxygen atoms spark a cascade of chemical reactions that ultimately produce tell-tale atmospheric beacons: hydroxyl and nitric oxide. Detecting these compounds, therefore, points to the existence of nitrogen and oxygen– and thus, the possibility of a habitable world, one needle in a vast haystack of exoplanets.

The study used an Earth science model to calculate just how much nitric oxide and hydroxyl would form and how much ozone would be destroyed in an Earth-like atmosphere around an active star. Scientists have used this model for decades to study how ozone — which forms naturally when sunlight dissociates molecular oxygen — in the upper atmosphere responds to solar storms, but it found a new application in this study. Incorporating data from NASA's Thermosphere Ionosphere Mesosphere Energetics Dynamics (TIMED) satellite, the researchers exposed their model atmosphere to the space weather they'd expect from a cool, active star. They found that ozone drops to a minimum and supplies the production of atmospheric beacons.

If detected on an exoplanet, the presence of the atmospheric beacon molecules also helps weed out exoplanets without an Earth-like magnetic field -- the magnetic field prevents atmospheric escape, so there are more particles in the atmosphere and a stronger resulting infrared signal.