Astronomers discover new clues to the 40-year-old mystery behind Venus's green glow

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Venus. Photo courtesy of NASA

Most of us have seen the aurora borealis, also called the northern lights, which paint the night sky with a multi-colored glow. These ghostly lights also show up in the southern hemisphere. But the light show on Venus is quite a different if you know where to look. A group of astronomers studying the phenomenon shared their findings at a meeting of the American Astronomical Society's Division for Planetary Sciences in November.

Candace Gray and Nancy Chanover of New Mexico State University in Las Cruces, NM, Tom Slanger of SRI in Menlo Park, Calif., and Karan Molaverdikhani of the University of Colorado at Boulder will share results that deepen the mystery of Venus, which may have a green aurora despite the fact it has no magnetic field of its own.

Aurora is generated when charged particles, such as protons and electrons from the Sun, are captured by a planet's magnetic field, funneled to the magnetic poles, and collide with atoms and molecules in the ionosphere, exciting them, which causes them to emit light. This light is seen in a variety of colors, including red, green, blue, and violet. The brightest color is green and is due to excited oxygen. The light is emitted in a very narrow wavelength, at 557.73 nm and referred to as the "oxygen green line." Also bright is the oxygen red line at 630.0 nm which is seen at higher altitudes than the green.

"On Venus, the green line has been seen only intermittently," said Candace Gray, a graduate student in astronomy at NMSU. "Sometimes it is very bright and other times it is not detectable at all. The reason for this variability has been studied for over forty years without a clear explanation for its cause."

On Earth, the aurora is also temporally variable, being bright one night and gone the next.

Venus's green glow was not assumed to be an auroral emission because, when it is detected, there is no associated auroral oxygen red line.

The brightest aurorae on Earth are observed after large solar storms, when the Sun produces large amounts of charged particles. The most intense solar storms are X-flares and coronal mass ejections (CMEs), large eruptions of plasma. Astronomers sought to determine if the Venusian green line is in fact, aurora being observed on a non-magnetic

planet.

"Using the high resolution Astrophysical Research Consortium Echelle Spectrograph (ARCES) on the 3.5-meter telescope at Apache Point Observatory (APO), we observed the Venusian nightside before and after major solar flares and CMEs," said Gray. "However, this is a very difficult set of observations given how many things have to go right in such a small observing window. Venus can only be observed for two two-month periods every 19 months."

For each two-month period, the team was given five nights to observe at APO.

X-flares are very rare. There may not be an X-flare for years during solar minimum and only a handful each year during solar maximum. Not only does an X-flare or CME need to occur in the two-month observing window, but it also needs to be directed at Venus, there must be enough time to notify the observatory staff, and there must be clear skies to observe. All of these requirements lined up for each of the four windows available from 2012 to 2014.

"Aphrodite, or even Zeus, were providing assistance in flare scheduling," said Slanger.

"The results were amazing! There was a major solar storm in July 2012, producing an X-flare and huge CME that was directed right at Venus. We saw the brightest green line that had ever been detected." After every CME impact the green line is detected, but not after every flare, suggesting charged particles are responsible for green line emission, similar to Earth's aurora.

But where is the emission coming from? The high altitude oxygen red line was not detected for even the brightest green line detections,

suggesting that the chemistry responsible for green line emission is occurring deep in the atmosphere where the oxygen red line does not emit. Are electrons able to reach deep enough in the atmosphere after CME impacts? To check, electron density observations taken by Venus Express were compared before and after CMEs.

Venus Express is a European Space Agency spacecraft orbiting Venus. It contains multiple instruments to observe the Venusian atmosphere and surface. Working with the Venus Radio Science team [Bernd Häusler (Institut für Raumfahrttechnik, Germany), Martin Paetzold, Silvia Tellmann, and Kerstin Peter (University of Cologne, Germany)], Candace compared observations of electrons after CME impacts. They found that higher energy electrons are entering the Venusian nightside atmosphere and, as predicted, the electron density does increase low in the ionosphere, around 125 km, where green line emission is possible but not red line.

"Further spectral observations along with electron energy and density observations before and after solar flares and CMEs are needed to determine if electron impact is the reason for the Venusian green line," said Gray. "The exact chemistry causing the emission is largely unknown."

Ground based and space based data are currently being used to model the Venusian ionosphere by Gray at NMSU, Olivier Witasse of the European Space and Technology Center in Noordwijk, Netherlands, and Pierre-Louis Blelly of Institut de Recherche en Astrophysique et Planétologie in Toulouse, France, in order to constrain possible chemical reactions.

"These are intriguing results, suggesting that it is possible to have aurora on non-magnetic planets," said Gray. "However, this may be unique to Venus because it is so close to the Sun at 0.7 AU. At that distance, the

solar storms are so strong that it may not matter if there's not planetary magnetic field, the charged particles would be deposited all over the planet, producing auroras at every latitude. It would be interesting to see if Mars, another non-magnetic planet with a CO2 atmosphere that is further away from the Sun, shows similar results."

Gray is proposing to compare the atmospheric response of Mars and Venus after major CME impacts to see how each planet responds to strong solar storms. While she will be using data from Mars Express, information from the new Martian spacecraft Mars Atmosphere and Volatile EvolutioN (MAVEN) will be invaluable. MAVEN has just entered into orbit around Mars and will be studying its atmosphere, including any possible aurora that may be generated after CME impacts.

Provided by New Mexico State University