UNIVERSITÄT BERN

Media Relations

Media release, 15 January 2020

Interstellar journey of life's building block phosphorus unveiled

Phosphorus, present in our DNA and cell membranes, is an essential element for life. But how it became available on the early Earth when life appeared here about 4 billion years ago is something of a mystery. For the first time, astronomers – among them researchers from the University of Bern – have now been able to show that molecules with phosphorus are formed in star-forming regions and probably came to Earth with comets.

New stars and planetary systems arise in cloud-like regions of gas and dust in between stars, making these interstellar clouds the ideal place to start the search for life's building blocks. "Life appeared on Earth about 4 billion years ago, but we still do not know the processes that made it possible," says the lead-author of a new study Víctor Rivilla from the National Institute of Astrophysics INAF in Florence. The new study, which was published today in *Monthly Notices of the Royal Astronomical Society,* shows that phosphorus monoxide is a key piece in the origin-of-life puzzle. Researchers from the University of Bern were also involved in the study, including Professor Emeritus Kathrin Altwegg from the Institute of Physics and Maria Drozdovskaya from the Center for Space and Habitability (CSH).

View with a giant telescope to star-forming regions

High on the Chajnantor plateau in the Chilean Andes, the European Southern Observatory (ESO), together with its international partners, is operating the Atacama Large Millimeter/submillimeter Array (ALMA) (see info box below). ALMA comprises 66 high-precision antennas working together in what is known as an interferometer. It allows a detailed look into the star-forming region called "AFGL 5142".

The ALMA observations showed, for the first time, that phosphorus-bearing molecules such as phosphorus monoxide are formed as massive stars come to life. Maria Drozdovskaya explains: "Flows of gas from young massive stars open up cavities in interstellar clouds. Molecules with phosphorus form along the cavity walls through photochemistry." The researchers have also shown that phosphorus monoxide is the most abundant phosphorus-bearing molecule in these regions.

In the star-forming regions phosphorus monoxide can freeze out and get trapped in ice surrounding interstellar dust grains, as new Solar Systems come to life. Even before Sun-like stars are fully-fledged, icy dust grains come together to form pebbles, planetesimals and ultimately comets.

Media Relations
Hochschulstrasse 6
3012 Bern
medien@unibe.ch

Interstellar journey from the stars via comets to the Earth

In order to follow the trail of these phosphorus-bearing compounds the researchers combined the data from ALMA with those from the Bern mass spectrometer ROSINA on board of the Rosetta probe of the European Space Agency (ESA), which had collected data from the comet 67P/Churyumov–Gerasimenko (see info box below).

Kathrin Altwegg, the Principal Investigator for ROSINA and an author in the new study, explains: "We had had found hints of phosphorus in the ROSINA data before, but we did not know what molecule had carried it there." She got a clue for what this molecule could be after being approached at a conference by an astronomer studying star-forming regions with ALMA: "She said that phosphorus monoxide would be a very likely candidate, so I went back to our data and there it was!"

"Phosphorus is essential for life as we know it," adds Altwegg. "As comets most probably delivered large amounts of organic compounds to the Earth, the phosphorus monoxide found in comet 67P may strengthen the link between comets and life on Earth."

This intriguing journey of phosphorus monoxide could be documented because of the collaborative efforts between astronomers. "The detection of phosphorus monoxide was clearly thanks to an interdisciplinary exchange between the data of the telescope ALMA on Earth by ESO and the data of the ROSINA-instrument in space by ESA," says Altwegg.

Publication details:

V. M. Rivilla, M. N. Drozdovskaya, K. Altwegg, P. Caselli, M. T. Beltrán, F. Fontani, F.F.S. van der Tak, R. Cesaroni, A. Vasyunin, M. Rubin, F. Lique, S. Marinakis, L. Testi, and the ROSINA team: *ALMA and ROSINA detections of phosphorus-bearing molecules: the interstellar thread between star-forming regions and comets,* Monthly Notices of the Royal Astronomical Society, https://arxiv.org/pdf/1911.11647.pdf

Further information:

Prof. em. Dr. Kathrin Altwegg
Physics Institute, Space Research and Planetology (WP), University of Bern
Phone: +41 31 631 44 20
Email: kathrin.altwegg@space.unibe.ch

Dr. Maria Nikolayevna Drozdovskaya
Center for Space and Habitability (CSH)
Phone: +41 31 631 34 43
Email: maria.drozdovskaya@csh.unibe.ch

The European Southern Observatory (ESO)

The European Southern Observatory (ESO) is the pre-eminent intergovernmental science and technology organisation in astronomy. It carries out an ambitious programme focused on the design, construction and operation of powerful ground-based observing facilities for astronomy, in order to enable important scientific discoveries. ESO also plays a leading role in promoting and organising cooperation in astronomical research. ESO operates three unique world-class observing sites in the Atacama Desert region of Chile: La Silla, Paranal and Chajnantor.
More information

ALMA: In search of our cosmic origins

High on the Chajnantor plateau in the Chilean Andes, the European Southern Observatory (ESO), together with its international partners, is operating the Atacama Large Millimeter/submillimeter Array (ALMA) — a state-of-the-art telescope to study light from some of the coldest objects in the Universe. This light has wavelengths of around a millimetre, between infrared light and radio waves, and is therefore known as millimetre and submillimetre radiation. ALMA comprises 66 high-precision antennas, spread over distances of up to 16 kilometres. This global collaboration is the largest ground-based astronomical project in existence.
More information

The European Space Agency ESA

Europe has been active in space travel and space exploration since the start of the space age. In 1975, the European Space Agency ESA was founded in which participating states pool and coordinate their activities. Switzerland was among the ten founding members of ESA; today it comprises 22 member states. Bernese researchers were appointed to ESA's advisory commissions very early on thanks to their proven expertise. Therefore, they also have an influence on which space projects and missions are chosen from the proposals submitted by the scientific community.
More information

The Rosetta mission

The mass spectrometer ROSINA was a key experiment undertaken by the Rosetta mission. For over two years, the Rosetta probe carried out a detailed examination of the comet 67P/Churyumov-Gerasimenko, called Chury for short, and in the course of this even landed a landing module on the surface of a comet for the first time ever. The mass spectrometer ROSINA (Rosetta Orbiter Spectrometer for Ion and Neutral Analysis) was developed, built, tested and telecommanded on the comet under the direction of the University of Bern. It was possible to determine many components of Chury's atmosphere – many of which for the first time on a comet. Thus, ROSINA made a significant contribution to the acquisition of new insight into the origin of our solar system. The mission's active phase came to a close in 2016 with the Rosetta probe's controlled crash on the surface of the comet Chury. However, since then, over 2 million data sets from ROSINA are still being evaluated in Bern and being made available to researchers across the world.
More information

Bernese space exploration: With the world's elite since the first moon landing

When the second man, "Buzz" Aldrin, stepped out of the lunar module on July 21, 1969, the first task he did was to set up the Bernese Solar Wind Composition experiment (SWC) also known as the "solar sail" by planting it in the ground of the moon, even before the American flag. This experiment, which was planned and the results analysed by Prof. Dr. Johannes Geiss and his team from the Physics Institute of the University of Bern, was the first great highlight in the history of Bernese space exploration.

Ever since Bernese space exploration has been among the world's elite. The numbers are impressive: 25 times were instruments flown into the upper atmosphere and ionosphere using rockets (1967-1993), 9 times into the stratosphere with balloon flights (1991-2008), over 30 instruments were flown on space probes, and with CHEOPS the University of Bern shares responsibility with ESA for a whole mission.

The successful work of the Department of Space Research and Planetary Sciences (WP) from the Physics Institute of the University of Bern was consolidated by the foundation of a university competence center, the Center for Space and Habitability (CSH). The Swiss National Fund also awarded the University of Bern the National Center of Competence in Research (NCCR) PlanetS, which it manages together with the University of Geneva.