# Lunar science is entering a new active phase

February 9 2024, by Jack Burns

The Intuitive Machines payload, which will contain materials for ROLSES, shown on the lunar surface in an illustration. Intuitive Machines, Inc.

For the first time since 1972, NASA is putting science experiments on the moon in 2024. And thanks to new technologies and public-private partnerships, these projects will open up new realms of scientific possibility. As parts of several projects launching this year, teams of scientists, including myself, will conduct radio astronomy from the south pole and the far side of the moon.

NASA's commercial lunar payload services program, or CLPS, will use uncrewed landers to conduct NASA's first science experiments from the moon in over 50 years. The CLPS program differs from past space programs. Rather than NASA building the landers and operating the program, commercial companies will do so in a public-private partnership. NASA identified about a dozen companies to serve as vendors for landers that will go to the moon.

NASA buys space on these landers for science payloads to fly to the moon, and the companies design, build, and insure the landers, as well as contract with rocket companies for the launches. Unlike in the past, NASA is one of the customers and not the sole driver.

## CLPS launches

The first two CLPS payloads are scheduled to launch during the first two months of 2024. There's the Astrobotics payload, which launched Jan. 8 before experiencing a fuel issue that cut its journey to the moon short. Next, there's the Intuitive Machines payload, with a launch scheduled for mid-February. NASA has also planned a few additional landings—about two or three per year—for each of the next few years.

I'm a radio astronomer and co-investigator on NASA's ROLSES program, otherwise known as Radiowave Observations at the Lunar Surface of the photoElectron Sheath. ROLSES was built by the NASA Goddard Space Flight Center and is led by Natchimuthuk Gopalswamy.

The ROLSES instrument will launch with Intuitive Machines in February. Between ROLSES and another mission scheduled for the lunar far side in two years, LuSEE-Night, our teams will land NASA's first two radio telescopes on the moon by 2026.

## Radio telescopes on the moon

The moon—particularly the far side of the moon—is an ideal place to do radio astronomy and study signals from extraterrestrial objects such as the sun and the Milky Way galaxy. On Earth, the ionosphere, which contains Earth's magnetic field, distorts and absorbs radio signals below the FM band. These signals might get scrambled or may not even make it to the surface of the Earth.

On Earth, there are also TV signals, satellite broadcasts and defense radar systems making noise. To do higher sensitivity observations, you have to go into space, away from Earth.

The moon is what scientists call tidally locked. One side of the moon is always facing the Earth—the "man in the moon" side—and the other side, the far side, always faces away from the Earth. The moon has no ionosphere, and with about 2,000 miles of rock between the Earth and the far side of the moon, there's no interference. It's radio quiet.

For our first mission with ROLSES, launching in February 2024, we will collect data about environmental conditions on the moon near its south pole. On the moon's surface, solar wind directly strikes the lunar surface and creates a charged gas, called a plasma. Electrons lift off the negatively charged surface to form a highly ionized gas.

This doesn't happen on Earth because the magnetic field deflects the solar wind. But there's no global magnetic field on the moon. With a low frequency radio telescope like ROLSES, we'll be able to measure that plasma for the first time, which could help scientists figure out how to keep astronauts safe on the moon.

When astronauts walk around on the surface of the moon, they'll pick up different charges. It's like walking across the carpet with your socks on—when you reach for a doorknob, a spark can come out of your finger. The same kind of discharge happens on the moon from the charged gas, but it's potentially more harmful to astronauts.

## Solar and exoplanet radio emissions

Our team is also going to use ROLSES to look at the sun. The sun's surface releases shock waves that send out highly energetic particles and low radio frequency emissions. We'll use the radio telescopes to measure these emissions and to see bursts of low-frequency radio waves from shock waves within the solar wind.

We're also going to examine the Earth from the surface of the moon and use that process as a template for looking at radio emissions from exoplanets that may harbor life in other star systems.

Magnetic fields are important for life because they shield the planet's surface from the solar/stellar wind.

LuSEE-Night, shown with its four antennas that will detect radio waves. Credit: Firefly Aerospace

In the future, our team hopes to use specialized arrays of antennas on the far side of the moon to observe nearby stellar systems that are known to have exoplanets. If we detect the same kind of radio emissions that come from Earth, this will tell us that the planet has a magnetic field. And we can measure the strength of the magnetic field to figure out whether it's strong enough to shield life.

## Cosmology on the moon

The Lunar Surface Electromagnetic Experiment at Night, or LuSEE-

Night, will fly in early 2026 to the far side of the moon. LuSEE-Night marks scientists' first attempt to do cosmology on the moon.

LuSEE-Night is a novel collaboration between NASA and the Department of Energy. Data will be sent back to Earth using a communications satellite in lunar orbit, Lunar Pathfinder, which is funded by the European Space Agency.

Since the far side of the moon is uniquely radio quiet, it's the best place to do cosmological observations. During the two weeks of lunar night that happen every 14 days, there's no emission coming from the sun, and there's no ionosphere.

We hope to study an unexplored part of the early universe called the dark ages. The dark ages refer to before and just after the formation of the very first stars and galaxies in the universe, which is beyond what the James Webb Space Telescope can study.

During the dark ages, the universe was less than 100 million years old—today the universe is 13.7 billion years old. The universe was full of hydrogen during the dark ages. That hydrogen radiates through the universe at low radio frequencies, and when new stars turn on, they ionize the hydrogen, producing a radio signature in the spectrum. Our team hopes to measure that signal and learn about how the earliest stars and galaxies in the universe formed.

There's also a lot of potential new physics that we can study in this last unexplored cosmological epoch in the universe. We will investigate the nature of dark matter and early dark energy and test our fundamental models of physics and cosmology in an unexplored age.

That process is going to start in 2026 with the LuSEE-Night mission, which is both a fundamental physics experiment and a cosmology experiment.



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