Early Work Underway On Advanced Science From Moon's Far Side

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Frank Morring, Jr.
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Early work underway on advanced science from far side of the Moon

Printed headline: Lunar Base

Lunar-science planners are beginning to work out the hardware issues involved in using the Moon as a base for outward-looking radio astronomy, as well as a scientific specimen to study.

The far side of the Moon is probably the most radio-quiet place in the Universe, shielded as it is by more than 2,000 mi. of rock from the cacophony of transmitters broadcasting from Earth's surface. And the Moon lacks an ionosphere that prevents many interesting radio frequencies from reaching terrestrial radio telescopes.

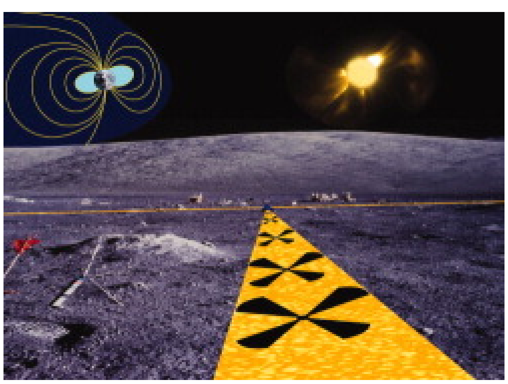
Radio astronomers hope to use those open skies one day to probe the structure of the Sun, and ultimately use their silence to examine the early Universe before the first stars lit up. To that end, NASA has funded a study to learn how to build a radio telescope on the Moon, along with other experiments that would use the unique vantage point of the Moon for scientific investigations.

"We just selected these various pilot programs looking 10 years ahead, what might we do back on the Moon," says Alan Stern, NASA associate administrator for science. "Those guys aren't actually building instruments yet. They're actually doing a study of what their candidate instrument will be like, what are the deployment issues, what are the operating and servicing issues."

Stern's office is also funding experiments that would use suitcase-size instruments on the lunar surface to test the general relativity theory, study X-rays produced when the solar wind interacts with Earth's magnetosphere, and provide clues to the Moon's interior structure (AW&ST Aug. 13, p. 18). But the radio telescope would likely pose the most serious development and deployment challenges for future lunar explorers, similar to what the defense industry faces as it develops conformal arrays for aircraft, ships and ground vehicles (AW&ST Oct. 30, 2006, p. 46).

The idea, says Naval Research Laboratory (NRL) radio astronomer Joseph *Lazio*, is to use an astronaut or robot to roll out a meter-wide sheet of polyimide film across the lunar surface like a red carpet that's 500 meters long. Deposited on the thin plastic sheet will be equally thin strips or patches of metal that would link up to turn the sheet of film into a long, narrow antenna.

Unroll two more long sheets to form a big "T" on the lunar surface, and you have a radio telescope big enough to produce radio-wavelength images in resolutions currently unobtainable.



Thin-film arrays rolled out like carpet across the lunar surface would form the antenna for a pathfinder radio telescope on the near side. Ultimately, scientists hope to build one measuring a square kilometer on the far side.Credit: NASA GODDARD SPACE FLIGHT CENTER CONCEPT

"The entire sheet could be rolled up so it would occupy a very small volume," *Lazio* says. "Our estimate for 500 meters would be 10 cm.

or 20 cm. in diameter, so I'm thinking more the size of a boy scout tent."

Overall the entire package for a pathfinder array would weigh about 100 kg. for a telescope with three arms and a small electronics package. That tracks with the Apollo lunar surface experiment packages of 100-150 kg., he says.

Initially, such a lunar radio telescope could produce new knowledge about the workings of the Sun, which is a big radio-frequency emitter. The goal would be to wring out the technology in a relatively small prototype not too far from NASA's planned polar moon-base, for a far-side deployment on a grand scale later.

Scientists want to use the prototype's lunar vantage point to study radio emissions from the Sun in the 1-10 MHz. wavelengths, which are blocked by Earth's ionosphere, to learn more about solar radio emissions associated with the coronal mass ejections that sometimes disrupt terrestrial communications and even power grids.

"There are actually some very fundamental things about that radio emission that still aren't well-understood, and they may have implications not only for the Sun and the Sun-Earth environment and things like that, but also for how do massive explosions take place elsewhere in the Universe," *Lazio* says. "So the notion is to study the particle acceleration, what's going on that's producing the radio emission sort of in our backyard, both with the idea that we would be able to understand something about the Sun and its impact on the Earth, as well as whether it will teach us anything about more distant mechanisms."

NASA has funded a team that includes the NRL, Goddard Space Flight Center, the Jet Propulsion Laboratory, the University of Colorado, Massachusetts Institute of Technology and the University of California-Berkeley, for a study aimed at better identifying the weight, power requirements and cost of a prototype system, and perhaps also to begin deployment testing of the antenna-on-a-roll concept. The $100,000 effort is to conclude in nine months.

Beyond the prototype telescope, which would be targeted for deployment in the 2020s, there could be a much larger far-side telescope aimed at literally peering into the period after the Big Bang when there were no stars and the Universe was mostly hydrogen.

"That hydrogen was neutral, but there were just the very first stages of what would become the galaxies today," says *Lazio*. The question is: "Can we essentially take pictures of the Universe before there were any stars, [when] we think the only thing around was this neutral hydrogen gas."

The lunar far side becomes important because when neutral hydrogen's 21-cm. radio transmission is red-shifted by the expansion of the Universe, it falls partially within the 88-107 MHz. frequency—the FM radio band. And even an FM station rated as low-power by the FCC is "blazingly bright to radio astronomers," *Lazio* says.

But without an ionosphere, and with the whole Moon between the radio telescope and Earth's radio transmitters, it may be possible to produce images of the first structure to form in the Universe.

"The sensitivity requirements of doing this are very challenging, so it's probably going to take a very large array, or a very large telescope," *Lazio* says, noting that very rough calculations suggest an array of 1 million square meters in area to get the desired resolution.

The lunar far side is attractive because it would be removed from most human activity on the Moon, which would rely on radio for communications and generate radio-frequency interference with its machinery. Lunar dust wouldn't be a problem for a large telescope, because the radio wavelengths of interest are so large that the telescope essentially wouldn't see any dust that might fall on it in the deployment process. And once the telescope is deployed, there are no moving parts to get jammed by dust particles, *Lazio* says.

Those considerations make radio astronomy a good candidate for lunar basing, says Stern.

"We're looking for particular killer aps, where the Moon really lets you do something either more easily, or better," Stern says. "In the case of radio astronomy, it's a better."