# Moon River

By Gerard K. O'Neill

We think of the moon as a dry, dusty place, But many scientists are hopeful that this desert may possess an oasis at each pole: shadowed craters with water ice.

In the early sixties, planetary scientists theorized that ice might exist in the shadowed regions of deep craters near the lunar poles. These craters may not have been exposed to sunlight for billions of years, beginning shortly after the creation of the moon. The hypothesis is that water vapor released by long years of baking in the sunlight may have collected in these natural cold traps, just as water vapor in a refrigerator condenses in the freezer section. Comets and fragments of asteroids, colliding with the moon, may also have deposited on the lunar surface water that made its way to the cold traps.

The discovery of water at the poles of the moon would accelerate space exploration and development by many years. Water found on the moon could be used by astronauts on the spot, and any needed in deep space could easily be lifted free of the moon's weak gravity, thus saving the enormous amounts of rocket fuel necessary to transport water from Earth. (Earth's gravity is so strong that in a space shuttle flight, we must burn almost 2,000 tons of rocket fuel to lift a mere 30 tons of payload into low orbit.) Furthermore, lunar water could be converted to pure liquid hydrogen and liquid oxygen — the best rocket propellant there is. All high-performance rocket engines burn liquid hydrogen and liquid oxygen. The moon is perfectly placed to be a natural refueling source, a gas station from which we could top off our rocket tanks before journeying farther.

Interestingly, though the moon was a major target of U.S. and Soviet space missions during the sixties and early seventies, little is known about the lunar poles. The landing sites of these missions were all near the lunar equator. All the Apollo and Lunokhod samples were excavated from sites near the equator — none from the permanently shadowed craters near the poles. If we were to construct a resource map of the moon today. we would have to label every region other than the belt around the equator, "unexplored."

Why have we not explored the mysterious regions near the lunar poles? The answer, not surprisingly, is a mix of government agency choices and funding. Decades ago NASA had planned to fly instruments over the lunar poles, which could have determined the presence of lunar water. NASA tried for years, most recently in the late seventies, to get budgetary approval for a Lunar Polar Orbiter mission. That plan, however, fell victim to federal budget crunches and NASA's choice to sacrifice nearly all its programs in order to get the space shuttle built.

NASA may someday fund a mission called the Lunar Observer, in which a large unmanned spacecraft would be sent to circle the moon's polar regions. It would be equipped to provide a chemical map of the entire moon and to search for water and other frozen volatiles in the shadowed craters. It would also conduct a dozen or more experiments aimed at solving other scientific puzzles. But the Lunar Observer mission is years away from fruition. In fact. it is not yet funded and may never be. At present a new branch within NASA, the Office of Exploration is examining the potential of this mission. and NASA officials anticipate making what they call a "pathway" decision in late 1991 or early 1992. That decision will determine the future of the U.S. government space program.

The Office of Exploration is considering a variety of scenarios for human activity in space. Among these are "Sprint" missions to Mars or its moon Phobos; a lunar far-side observatory that could be visited for two weeks each year, or a permanent lunar outpost that could serve as a springboard to the entire solar system. Unfortunately, the decision on where and how to proceed in space may be made without first knowing whether there is water on the moon. If we could learn this before the "pathway" decision at NASA is made, our nation could save billions of dollars.

Recognizing the vital importance to all future space programs of finding out whether there is water on the moon, the National Commission on Space has strongly recommended that we send a small robotic probe to look for water and for other lunar volatiles. such as oxides of the life elements carbon and nitrogen. Is there any way that such a probe could be flown in time to assist the NASA "pathway" decision? The answer is yes. NASA's Jet Propulsion Lab (JPL) in Pasadena, California, and the Space Studies Institute (SSI), a nonprofit foundation located in Princeton, New Jersey, have investigated how to send a water-searching space probe to orbit the moon. They have found that there are at least two ways.

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Both JPL and SSI have studied a small spacecraft that would carry an existing instrument, a gamma-ray spectrometer left over as surplus from. the Apollo program. The spectrometer would be surrounded by a layer of material enhancing its sensitivity to gamma rays from hydrogen. Those gamma rays are emitted because all lunar surface materials are bombarded constantly by cosmic rays. JPL investigators have proposed that this space probe, called Quicksat Lunar Prospector, would deliver its payload to lunar orbit about three days after launch. Once in orbit, it could determine within two weeks whether water exists at the lunar poles.

A small team at JPL has also come up with an ingenious alternative to the Quicksat mission. If the solid rocket motors of the Quicksat could be replaced by ion-drive engines, which are compact and perform better than chemical rockets, the entire Lunar Polar Probe could be squeezed into a package small enough to fit into a space shuttle Getaway Special canister. (And, fortunately, NASA charges only $10,000 for flying them.)

When safely clear of the shuttle, the Lunar Polar Probe would extend wings of solar cells, each ten meters long. The electricity from the solar cells would power its ion engines. The probe would be light but slow to accelerate. Its resulting low thrust, capable of being sustained for a long time, would bring the probe to lunar polar orbit in a flight time of about two years. The trajectory would be spiral out of the earth's gravitational field and then spiral into the moon's. The advantage of the ion-drive alternative is that there would be little cost for launch.

It is tremendously exciting to realize what little effort, compared with the scale of typical space missions, is required to send a polar probe to the moon. Such an expedition would do more than solve the moon's greatest mystery — whether it possesses its own water. By providing a watering and refueling oasis beyond Earth's orbit, it could also save us billions of dollars in the years of exploration to come, money that could be spent far more productively on future space missions and on enabling us to reach the high frontiers of space.