gram to move more quickly toward collecting rocks from such sites by shifting some resources from climate and mapping data and ramping up its plans to send rovers capable of characterizing sites and collecting the appropriate samples. Although some NASA officials had initially suggested pushing up a sample return mission to as soon as 1998, McCleese said even 2001 is probably too soon "at the present pace of planetary business. But we are seriously looking at a 2003 sample return," he said, contingent on funding. "If the public says move ahead [with a 2003 sample return], there's no scientific or engineering impediment. But there's definitely a resource issue."

The most important scientific and technical factors in planning the revamped program are site selection, rovers, and sample return. Orbiters and rovers should examine the mineralogy of rocks, the group said, and carry sensors that could detect signs of a "warm, wet spot" containing potential ingredients for extant life, such as methane or water vapor. Rovers should be able to do shallow digging, break open rocks, perform simple microscopy, and gather samples. The group also discussed how to prepare samples and avoid contamination, including keeping in quarantine any samples brought back. And they talked about the elements of a future mission to Mars by humans to do deep drilling and coring if it proves necessary.

To begin accomplishing these tasks, the researchers suggested that NASA tinker with its upcoming budget, now being debated by Congress. The scientists also expect help from overseas; Russia, for example, plans to send a rover to Mars in 2001 as part of a joint mission with the United States, and NASA hopes the rover can be designed to fit the new thrust of its exploration efforts. Finally, the group will recommend that NASA beef up its program jointly with the National Science Foundation to find more meteorites like ALH84001 in Antarctica.

The odds of finding more evidence for past or present life in rocks and soil from Mars will depend on the right choice of samples, the scientists agreed. Indeed, University of California, Los Angeles, planetary geologist David Paige urged the group to wait until at least 2005 for a sample return and spend the extra time developing spacecraft better able to pick out a promising array of materials.

Over the next month the researchers will consult with other scientists and NASA engineers about how many rovers and launch vehicles should be sent, and when. At the end of September the group will present its recommendations to an outside panel that advises NASA's office of space science. This, in turn, will feed into a space summit the White House is planning in December.

–Jocelyn Kaiser

MEETING BRIEFS

Scientists Plan Mercury Probe and Earth Satellite Campaign

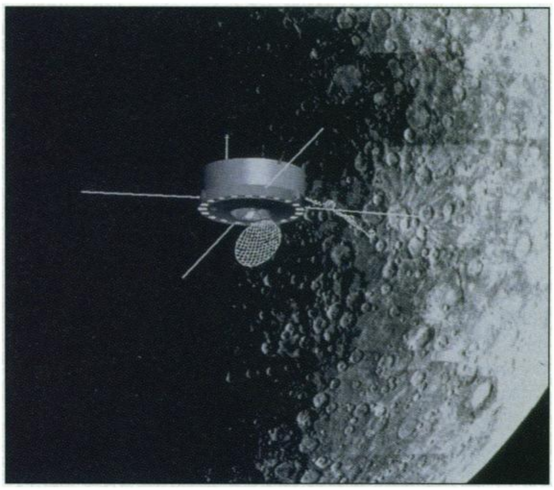
BIRMINGHAM, U.K.—Last month the international Committee on Space Research (Cospar) met here for its 31st annual meeting. The immediate show stealers were the latest results from NASA's Galileo spacecraft, currently touring the Jovian system, and Europe's SOHO spacecraft, now in orbit around the sun. But the conference also offered previews of projects that will eventually edge those widely publicized missions off the stage: a voyage to Mercury and a multinational campaign to study Earth's magnetosphere.

Return to Mercury

Unbowed by the loss of the Cluster spacecraft—destroyed when Europe's first Ariane 5 launcher blew up in June—the European Space Agency's (ESA's) science program is preparing to approve a billion-dollar mission to Mercury that owes more than a few debts to Cluster. The Mercury mission will draw heavily on technology developed for the ill-fated craft, and it too will target a planetary magnetosphere, a region in which a planet's magnetic field—in this case Mercury's—governs the behavior of charged particles. By comparing Mercury's magnetosphere with Earth's, which Cluster was meant to study, scientists hope for new insights into how the wind of particles streaming from the sun interacts with planetary magnetic fields.

In addition to rich pickings for space plasma physicists, the as-yet-unnamed mission will yield data about solar system evolution and planetary formation. By satisfying two large communities of space scientists, the Mercury mission has become a hot favorite to be the first cornerstone mission in ESA's Horizon 2000 Plus science program, a new round of large and medium-size missions due to begin around 2005. Physicist Hans Balsiger of the University of Bern in Switzerland, who became chair of ESA's Science Program Committee (SPC) last month, says that his committee is almost certain to endorse the Mercury mission at its next meeting in November. Had Cluster not been destroyed, forcing delegates to focus on a possible makeup mission (*Science*, 28 June, p. 1866), the SPC would have done so at its meeting last month, says Balsiger, who chaired a Cospar session on proposed future planetary missions.

The last mission to Mercury was the U.S. spacecraft Mariner 10 some 20 years ago. Scientists have exhausted Mariner's data and are now eager for fresh observations to help them answer questions raised by the mission. Physicist André Balogh of London's Imperial College first put forward the idea of a European return to Mercury in 1993. He led 19 European scientists in a feasibility study of the project that defined in general terms the scientific aims and technical constraints. "We initially were proposing that the mission be one of the agency's Medium missions [which have a price tag of about $460 million], but it soon became clear that a trip to Mercury would cost much more," says Balogh.


ESA

In the hot zone. Artist's conception of Mercury orbiter.

Technical challenges are what push the price tag into the billion-dollar bracket. Because Mercury is very close to the sun, a spacecraft visiting it will experience intense solar heating, requiring heavy insulation and some active temperature control. What's more, the sun is a powerful radio source that could swamp signals from the probe. To hold its own against the sun's radio noise, it will need sophisticated high-gain antennas.

Nor is it going to be easy to get there. Mercury's proximity to the sun means that its orbital velocity is much higher than that of the outer planets. As a result, the spacecraft will have to accelerate to great speed to catch the planet and then slow down drastically to enter an orbit around it—all of which will burn a lot of fuel. The technical legacy of Cluster will lend a hand here: All four Cluster spacecraft were designed to carry about half of their weight as fuel to enable them to reach and maintain their positions in the far reaches of the magnetosphere.

Even so, the Mercury craft will have to take advantage of four gravitational assists on its nearly 4-year journey to Mercury, swinging twice around Venus and twice around Mercury to reach its final orbit. Such tortuous paths are not easy to navigate, but the celestial odyssey of the Galileo spacecraft around Jupiter and its moons has made mission planners confident that it is possible. "We have been playing table tennis with the planets quite successfully recently," says Balogh.

After reaching Mercury, the orbiter, which is intended to be active for 9 months (three Mercury years), will go into an orbit that passes over both poles. With Mercury rotating below it, the spacecraft will eventually survey the entire surface of the planet. It will compile a comprehensive map of Mercury's surface and gather data on the surface composition and charged particles. The craft will also map the magnetic field strengths it encounters as it orbits the planet—data that may help planetary scientists solve a puzzle that has lingered since Mariner: the nature of Mercury's core.

Prior to Mariner's visit, planetary scientists expected Mercury's core to be small and consist of solid iron. Because a churning core of liquid metal is needed to generate a strong magnetic field like Earth's, Mercury's field was expected to be weak and comparatively simple. Yet it turned out to be strong and complex enough to create an active magnetosphere. Now planetary scientists are hoping that the distribution of magnetic field strengths measured by the ESA mission will show what kind of core could be setting up the complex pattern of field lines. One possibility is that the core contains a large fraction of sulfur—a composition that would run counter to current theories of solar system formation.

Plasma physicists, for their part, hope that the observations of charged particles and magnetic fields will resolve another question raised by Mariner: how electric currents flow through Mercury's magnetosphere. These currents are set up as Mercury flies through the stream of charged particles from the sun, but in order to flow, they must somehow form a closed circuit around the planet. On Earth the circuits allowing current to flow through the magnetosphere are closed via the ionosphere, conductive layers in the upper atmosphere where solar energy strips electrons from atoms and molecules of air. But Mercury does not have an atmosphere and thus has no ionosphere. "Mercury has a thin exosphere of sodium and potassium ions," says Andrew Coates, a space plasma physicist at University College London's Mullard Space Science Laboratory and one of the scientists who worked on the initial mission proposal, "but this is not dense enough to close the circuits. It could be that circuits are closing via the surface," which may be conductive.

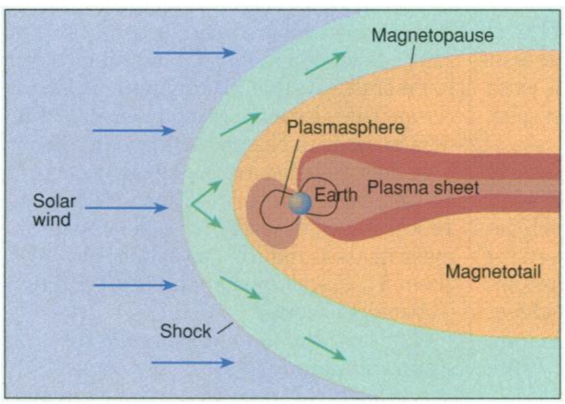
Because Mercury's magnetosphere must work differently from Earth's, it should provide a useful point of comparison for physicists trying to understand the basic features of planetary magnetospheres, Coates adds. Further, says Balogh, the combination of a weaker magnetic field and a stronger solar wind—its pressure at Mercury is some 10 times that at Earth—means that in both space and time, the scale of events in Mercury's magnetosphere must be different from those in Earth's.

Although the planets will be aligned in a way that makes the mission's complicated itinerary possible every year or two for the next 15 to 20 years, the alignment that will give the craft the biggest boost, and hence allow the smallest fuel load, will occur in 2009. From a space scientist's point of view, less fuel means more scientific payload, so Balogh favors the 2009 launch date. "Even if I am close to retirement by the time of the mission," he says, "I still hope to crack a bottle of champagne."

All Eyes on the Magnetosphere

It's a fortuitous alignment of celestial bodies—artificial ones, in this case. Three spacecraft, U.S., Japanese, and Russian, are now exploring Earth's magnetosphere, pursuing their scientific goals independently. Space physicists, however, have long wanted to coordinate their observations of this vast envelope of charged particles, which is governed by Earth's magnetic field and draws energy from the solar wind. This winter they will get their chance, when the spacecraft will be ideally positioned to work in concert.

Seizing the opportunity, NASA's Goddard Space Flight Center in Greenbelt, Maryland, has proposed a 3- to 5-month coordinated international observing effort. Says Robert Hoffmann of Goddard, project scientist for Polar, one of the three satellites: "The configuration of the satellites will be especially good for solar-terrestrial physics." NASA put the proposal to the Interagency Consultative Group, an international coordinating body, during the Cospar meeting. The idea is that investigators from all of the spacecraft will submit data in an agreed format to NASA, and it will be available to the scientific community from Goddard. Hoffmann is confident that the campaign will go ahead.



In the spotlight. Features of the magnetosphere.

The three spacecraft involved—Russia's Interball and Japan's Geotail, along with Polar—all follow orbits that take them deep into the magnetotail, the cometlike region of the magnetosphere that stretches away from Earth, downwind of the sun. In the magnetotail, the solar wind stretches out the magnetic field lines like a banana being peeled, storing energy, says Andrew Coates of University College London's Mullard Space Science Laboratory. From time to time the energy is discharged, causing turmoil closer to Earth. Charged particles are pumped into nearby radiation belts and down magnetic field lines into the auroral zones over the poles, causing the aurora to brighten.

The details of these events are not well understood, however, because to date scientists have been able to see them from only one vantage point at a time. But this winter, the orbits of Geotail and Interball will allow them to study events simultaneously both at the boundary between the magnetotail and the solar wind and within the magnetosphere. At the same time, Polar will be orbiting over the northern polar region, where it can monitor events in the auroral zone.

The three main spacecraft will get some help from two probes outside the magnetosphere. One of them, Europe's SOHO spacecraft, monitors the sun from a vantage point sunward of Earth; its observations should enable researchers to keep track of events at the solar surface, which pump energy into the solar wind. NASA's WIND satellite, which is also stationed upwind of Earth, will measure the resulting disturbances in the solar wind, helping scientists pin down the driving forces of activity within the magnetosphere.

Rounding out the effort will be American and European ground-based radars located in arctic regions, which will observe particle densities near Earth. If NASA is successful this week with its planned launch of the Fast Auroral Snapshot Explorer, that spacecraft, too, will join the effort, taking minute-by-minute particle measurements. For solar-terrestrial physicists, the conjunction of so many observing efforts can only be a favorable omen.

–Helen Gavaghan

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