Science News of the Week

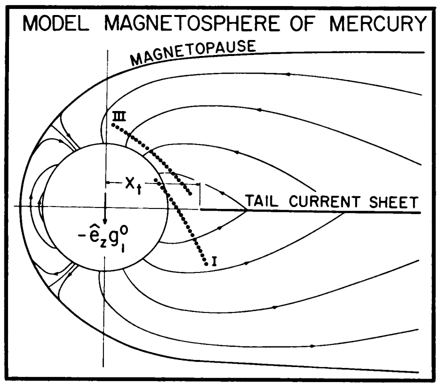
Mercury's Magnetism Is Its Own

"Unquestionably," says Norman Ness. "Unequivocally," says James Dunne. Surviving a knuckle-whitening last-minute cliff-hanger, the crippled Mariner 10 spacecraft this week revealed that the magnetic field of Mercury, a complete surprise when the probe first detected it a year ago, is definitely the planet's own, intrinsic to Mercury, rather than something generated from outside by some complex interaction with the solar wind.

Mariner barely lasted long enough to tell the tale. From the very day of its Nov. 3, 1973, launching, when balky heaters threatened to let its two TV cameras freeze solid, the probe was assaulted with a seemingly endless succession of woes. The most recent was a severe tracking problem that threatened to wipe out this week's third encounter with only two days to go. More than any other planetary mission on record, in fact, Mariner 10 has brought out the best in its human crews, who have staved off innumerable potential tragedies to convert ever-looming disasters into a two-planet, four-encounter triumph.

The third and final encounter with Mercury (which was so down-to-the-wire that Mariner will probably run out of control gas by the end of this week) was originally no more than a promising bonus, made possible by an accident of celestial mechanics. But the discovery of Mercury's magnetic field during the first encounter last March 29 gave new importance to the third visit (the second pass, on Sept. 24, was too far from the planet to help). In this third pass Mariner skimmed by only 323 kilometers from the newly intriguing world. The earth's much more powerful magnetic field, points out Ness, of the Goddard Space Flight Center, blocks the solar wind at a distance equal to about 15 times earth's radius. Mercury's little field, however, forms its solar wind shock wave less than half a Mercury radius out from the planet's surface; in other words, the planet itself occupies most of its magnetosphere, making a close flyby a necessity.

It would have paid off even if it had only answered the one big question. But besides showing that the field is intrinsic, says Ness, the data from the final pass may also have made it possible to shed some light on why it is there at all. One possibility is that Mercury is composed in part of permanently magnetized rock, but this, Ness



points out, "requires a very special sequence of events occurring during the formation and evolution of the planet." Even so, he says, a comparison with Apollo lunar samples suggests that a 300- to 600-kilometer-thick crustal shell with similar magnetization could account for the observed field strength. The more likely source, he implies, is an active "dynamo" of spinning electric currents within Mercury's iron-rich core. Detailed studies of the first and third encounters should help. But the dynamo idea "faces some difficulties because we are uncertain about the exact structure" of Mercury's interior.

The surface is better known, thanks not only to Mariner 10 but to ground-based work as well. T. B. McCord and F. Vilas of Massachusetts Institute of Technology reported as long ago as 1972 that the surface was moon-like, basaltic, rich in iron and titanium and partially smoothed by the effects of "shock weathering." Last month, Rob Landau of the University of California added the finding, from thermal polarization studies, that the surface may be loosely packed on a scale of centimeters or meters but that the loose particles seemed to be composed of smaller structures that are compact on the scale of microns.

One particularly important contribution of the close flyby, points out Clayne Yates of JPL is in the form of evidence showing that one characteristic of Mercury, notably its charged-particle populations, can be reasonably compared with the earth's. Electron fluxes, for example, show similar distributions around both worlds given the different scales of their magnetic fields, says Yates. Occasional bursts of charged particles originating in Mercury's magnetic tail, adds University of Chicago's John Simpson, also resemble their earthy counterparts. Such data could become important if it becomes necessary to rework ideas about the earth, such as the out-of-hand assumption that it is earth's rapid rotation that makes possible its magnetic field, in the light of new insights into slowly turning Mercury.

Mariner 10 data will keep researchers going for a long time; they'll have to, since the National Aeronautics and Space Administration has no present plans to return to Mercury before the late 1980's. But the team that made it all possible is already fast fading from view. Project scientist James Dunne and project manager Gene Gibberson, for example, are even now at work on the 1978 ocean-monitoring satellite called SEASAT. The 110-person complement of flight controllers was down to about 35 before the final encounter, and, says Dunne, "Viking [the upcoming Mars-landing mission] is swarming all over the control area now, kicking us out." □

Helios makes closest pass to sun

Last Sept. 21 during its second encounter with Mercury, Mariner 10 reached within 68,314,000 kilometers of the sun. Not even Venus probes had previously come as close to the sun as 100 million kilometers, but now all previous record keeping has become academic. Less than a month ago, on Feb. 25, the German-built solar probe called Helios (SN: 8/3/74, p. 74) smashed Mariner 10's record, and last Saturday it reached its own closest point, some 46,291,060 kilometers from earth's home star.

At such proximity, about 30 percent of the earth's mean distance from the sun, water would have long since boiled away. Lead would melt. At perihelion, Helios was bathed in 11 times as much solar energy as ever reaches earth's atmosphere, and the temperature hovered around 700 degrees F.

Yet the hardy spacecraft is surviving. In fact, says Gilbert Ousley who manages the U.S. side of the predominantly German project from NASA's Goddard Space Flight Center in Maryland, "it works better in space than it did on the ground." So exhaustive an effort went into developing the craft that officials at the German Space Operations Center near Munich referred to it as "Germany's Apollo."

All the way to perihelion, Helios's components have stayed within about 3 degrees of temperature of its designers' predictions, a remarkable accomplishment considering its previously unsampled environment. Even the antenna wires, almost the only noninsulated bits, were right on the money. One magnetometer, mounted outboard on a boom to measure the interplanetary magnetic field, is slightly warm, possibly due to solar radiation's changing the color of its insulation, but its data are reportedly good and it shows no signs of cooking.

The data themselves are harder to come by. German officials have decreed that no results will be discussed until all of the Helios scientists have met to make a joint presentation at an international scientific meeting in Bulgaria in June. One researcher, mentioning the not-particularly-surprising fact that Helios had detected earth's considerable radio noise for about 30 days after launch, felt compelled to request anonymity in disclosing the "revelation."

But even the questions are fascinating. In 1969, for example, the IMP-8 satellite, orbiting the earth, detected radio emissions from the direction of the sun only moments after the eruption of several solar flares. Yet the radio waves seemed to spring into being more than 45 million kilometers out from the sun. Somehow the plasma waves driven outward by the flares trigger radio waves that don't appear until two-thirds of the way to Mercury's orbit. Why? Only Helios is close enough to tell.

One of the probe's major innovations is a device called a "shock memory" which automatically stores all the instrument readings taken for 15 seconds after *and before* it is triggered by the passing wave front of a solar flare. The recorded data, which are taken at a much higher ratio than Helios transmits information, can then be slowed down and played back to earth at the more leisurely transmission speed.

Helios has a lot of friends in the sky, although much farther from the sun, which together enables solar phenomena to be studied at different positions in space. The IMP-8 satellite includes azimuth information as well, while another called Hawkeye records elevation angles along with its data. Combined with Helios, they provide what amounts to a stereoscopic view of the sun and its environs.

On Dec. 8 Helios B is scheduled to be launched on a path similar to the 95-day solar orbit of its predecessor. If the present probe's temperature readings stay on their predicted curves, Helios B may go as much as 900,000 kilometers closer to the sun. □

Colliding beams, the future of physics

Particle physicists and the accelerator-building specialists who work with them have made storage-ring facilities for colliding beams of elementary particles work in spite of some initial dubiety. Now they are strongly fascinated with them. This is apparent not only from the attention storage rings got at last week's 1975 Particle Accelerator Conference in Washington but also from the choices made by those who hope to build new accelerators in the near future. In the United States and Western Europe at least, it's almost all colliding beams.

The reason for the fascination is economy of energy. When two beams of accelerated particles collide head on, all the energy they carry is available for the formation of new particles and other processes that physicists want to study. In the earlier type of accelerator a single beam of particles is sent against a stationary target. There much energy is invested in forward motion. One of the basic laws of physics is conservation of momentum, which means that the momentum before the collision must remain the same after, so the forward motion continues in the same amount as before, and a good deal of energy is withheld from interesting processes. Two beams of equal and opposite momentum stop each other cold when they collide—the total momentum in the system is zero—so all the energy is available for other things. (In practice not quite. To engineer the thing the beams have to be made to cross at a slight angle, but still the saving is tremendous.)

Up to now storage rings have come in two varieties—electron-positron and proton-proton—because the technology for accelerating and storing the two kinds of particles is different, but there is nothing really to stop accelerator builders from adding a proton ring to an electron-positron facility or vice versa. This is proposed in a few of the projects under consideration, and it would give the opportunity for proton-electron or even proton-positron collisions, an experiment that ought to reveal hitherto unreachable ultrafine details of the proton's structure.

West European physicists have floated suggestions or made detailed plans for four new colliding-beam facilities, three basically electron-positron and one proton-proton. American physicists' hopes include two electron-positron facilities and two proton-proton. What may be planned in Eastern Europe is not known. A representative from the Soviet Union was invited to the symposium, but none came.

Two of the West European electron-positron proposals, one in England and one in West Germany, appear to be most viable at the moment, according to Kjell Johnsen of the CERN laboratory in Geneva. The third, in Italy, has run into heavy weather from the Italian funding authorities, but the Italian physicists are keeping the idea alive in the hope of some kind of possible international funding.

The British project, planned for the Rutherford Laboratory and called EPIC, and the German, planned for the Deutsches Elektronen-Synchrotron at Hamburg and called PETRA, are basically similar as is to be expected in machines of the same generation built for the same general purpose. Both aim for between 10 billion and 20 billion electron-volts (10 to 20 GeV). EPIC would collide two 14-GeV beams, PETRA two 19-GeV beams. Currently operating e-p machines are all under 5 GeV per beam. Both would be large squared-off ovals about two kilometers across. Rings of that size cause siting problems in the densely populated areas where the two laboratories are located, and the solution in both cases is identical: run the new ring around the existing laboratory buildings. (European physicists drool with envy when they see the lavish grounds of American accelerator laboratories.)

The Italians, who were among the earliest to start storage rings, first with Ada (*Anello d'accumulazione*, Italian for storage ring) and now with the currently operating Adone (*Ada* plus the suffix *one*, meaning the same only bigger), one of three few-GeV e-p machines in the Western world, floated a proposal for a Superadone to collide two 10-GeV beams. But it got such a bad reception from the Italian science funders that further planning is much discouraged.

Johnsen stresses that particle physics in Europe is a matter of international cooperation even where strictly nationally funded and managed laboratories such as these are concerned. Ironically the result of that cooperation is likely to be that only one of these proposals will ever be built.

CERN already has one set of colliding-beam rings for protons. They are fed protons up to 30 GeV by the existing Proton Synchrotron. CERN is now building a Super Proton Synchrotron, a 400-GeV machine, which will be the counterpart to the machine of the same energy at the Fermi National Accelerator Laboratory in Illinois. Some planning has been done for storage rings to take 400-GeV protons from that. Two possibilities are under study, one with normal magnets, one with superconducting magnets. Both would be huge, the normal option requiring two rings