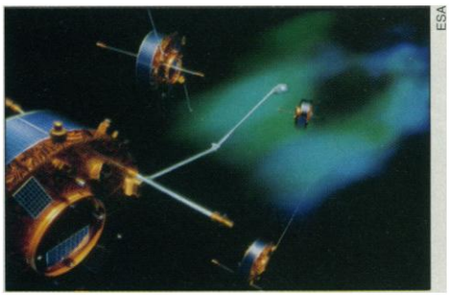
EUROPEAN SPACE SCIENCE

# New Launcher to Lift Off With Armada of Plasma Probes




**Formation flying.** Cluster spacecraft will study the magnetosphere in 3D.

**BRUSSELS**—Next week, if all goes according to plan, Europe will launch the first of its Ariane 5 rockets—the new workhorse of the European space program, capable of lofting up to 23 tons of payload into orbit. But next Thursday's launch from Kourou in French Guyana marks more than just the inauguration of a new launcher; it will also be a milestone in the European Space Agency's (ESA's) science program. Ariane 5's first payload consists of four identical satellites, collectively known as Cluster, which will fly in formation around Earth studying in unprecedented detail its magnetosphere and the stream of particles from the sun that pounds it around the clock. Cluster and SOHO, a solar observatory ESA launched last December, together form the first large "cornerstone" mission of ESA's ambitious Horizon 2000 space science program.

"We are trying to understand the nuts and bolts of the magnetosphere, how it really works," says principal investigator (PI) André Balogh of Imperial College in London. The magnetosphere is a region around Earth where the planet's magnetic field deflects the constant bombardment of particles from the solar wind—a stream consisting mainly of protons and electrons. It is a region of intense activity that can only be studied from space because the magnetic field blocks solar particles from reaching Earth, while the lower altitude ionosphere filters out most of the radio waves generated by the turbulent plasma.

To plasma physicists, the magnetosphere is a huge plasma laboratory. "It is an environment in which you can study plasma physics that you couldn't study in any other way, because it is essentially unconfined, compared to the laboratory," says co-investigator Andrew Fazakerley of London's University College. To study the wealth of physical processes taking place in the magnetosphere, Cluster's designers have equipped the spacecraft with a battery of 11 instruments, some of which will make their debut in space on this mission. But the most important feature of this mission is the launch of four identical spacecraft flying through space in tetrahedral formation and making identical observations from different positions—a first in space research. "It gives us the opportunity to measure plasma structures in three dimensions," says Rudolf Schmidt, Cluster's project scientist at the European Space Research and Technology Centre in Noordwijk, the Netherlands.

Before any of these measurements could be attempted, however, Cluster's designers had to overcome a major problem: Charged particles from the plasma stick to the spacecraft, charging them to a potential of few volts. This is a problem if you want to measure the energy of slow particles, because the charge on the spacecraft either repels or accelerates them, biasing the measurements. The solution was an instrument called Active Spacecraft Potential Control (ASPOC), which controls the potential of the spacecraft by ejecting positively charged indium atoms into space using an electrostatic field, in much the same way that ink droplets are ejected by an ink-jet printer. But ASPOC also acts as an experiment: The amount of indium required to balance the potential tells researchers how much charge the spacecraft is accumulating. "We are investigating how the plasma is collected by the spacecraft, how the charging and discharging process is taking place—you can call it sort of an active experiment," says ASPOC's PI Willibald Riedler of the Space Research Institute of the Austrian Academy of Sciences in Graz.

The Electron Drift Instrument (EDI) on the satellites will also be shooting out beams, in this case electrons, in an effort to study the electric field in the magnetosphere. The magnetic field will exert a force on the moving electrons, bending their path into a huge circle, sometimes a few kilometers across. The electric field also exerts a force, perpendicular to the circle, which bends the electrons' path into a helix. Depending on the electric

## Space Scientists' New Workhorse


**Rollout.** Ariane 5 prepares for its debut.

When the European Space Agency (ESA) was founded 21 years ago, one of the key objectives was to provide Europe with independent access to space. The enormously successful Ariane program is the result of that principle: There have been 80 Ariane launches to date, depositing a total of 134 spacecraft into orbit, and Ariane now accounts for more than 50% of the world's commercial satellite launches.

That success is based on a keep-it-simple strategy, in contrast to the very high-tech approach adopted for NASA's space shuttles. Designers are continuing with the strategy for Ariane 5. "We have designed a simple launcher," says Jacques Durand, Ariane 5 program manager at ESA headquarters in Paris. (Although launches are now managed by the commercial company Arianespace, ESA still carries out launcher development for the program.) "There are not many engines: We start the Vulcan engine, which works with liquid hydrogen and oxygen, on the ground so we can verify its functioning before launching the rocket."

Most of the thrust during the launch is delivered by two solid boosters, also chosen because of their simplicity. "The second stage is also very simple because the fuel we use ignites spontaneously, and there is no turbopump, so there are no rotating parts," adds Durand, who expects that the launcher will have an active life of 20 years. But studies are under way for a lighter and more powerful design.

In addition to the commercial success of the Ariane series, the launchers have lofted a large proportion of Europe's scientific spacecraft, and Ariane 5 is key to ESA's series of large "cornerstone" missions in its Horizon 2000 science program. Following Cluster (see main text), Ariane 5 will carry the X-ray Multi-Mirror Mission in 1999, the Far Infrared and Submillimeter Space Telescope in 2005, and Rosetta, scheduled for an encounter with comet Schwassmann-Wachmann 3 in 2010. With so much riding on the Ariane 5, Europe's space scientists will be watching anxiously as it makes its maiden flight next week.

–A.H.

field strength, this displacement can range from a few centimeters to a few kilometers. But because of the motion of the spacecraft, "there is always a very well-defined single direction in which we have to fire the beam and it returns to the spacecraft," says EDI PI Goetz Paschmann of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany. "The name of the game is that you need to search for that point." By studying the size of the circle and the amount of displacement, researchers can ascertain the strength of the electric field.

PI Donald Gurnett of the University of Iowa will use the four spacecraft as a radio interferometer, just as radio telescopes on Earth can be linked and their signals combined to increase spatial resolution. One of his targets will be the auroral kilometric radiation, huge outbursts of radio waves with signal strengths up to 1000 megawatts, which are completely shielded from detection on Earth by the ionosphere. "We live here on the ground with this tremendously powerful radio source above us in the auroral region, but we cannot detect it. If we lived on Mars we might be radio astronomers studying the Earth as a radio source," says Gurnett.

Another prime area of study will be the bow shock region, where, like water hitting the bow of a ship, the solar wind impacts on Earth's magnetosphere and is forced around it. The International Sun-Earth Explorer, twin satellites launched in 1977, detected spikes of intense electric field in this region with durations of just 50 milliseconds. "We hope to be able to catch these spikes and to analyze them in detail," says PI Georg Gustafsson of the Swedish Institute of Space Physics in Uppsala.

The little-explored regions of the polar cusps—where Earth's magnetic field funnels some of the solar wind down to within a few kilometers above the poles—will also come under particular scrutiny. "A lot of key phenomena people have predicted will happen in the cusps, and to go there and really check that out will be very important," says Fazakerley. This will also lead to a better understanding of the origin of auroral displays such as the Northern Lights—the most well-known manifestation of the tumult going on just above our heads. If the Cluster mission lives up to physicists' expectations, it should provide a unique view of this tumult. "The big effects [in the magnetosphere] are understood. We are now looking for the underlying physical processes. We will see whether the physical laws that people apply really hold," says Schmidt.

**–Alexander Hellemans**

*Alexander Hellemans is a writer in Brussels, Belgium.*

ITALIAN SCIENCE MINISTER

# A Second Spell in the Science Hot Seat

VENICE—After a year and a half of government by nonpartisan "technocrats," Italian voters restored politicians to center stage late last month, selecting a center-left government that, for the first time, has a strong complement of former communists. Last week, the new government announced that it would form a "superministry" responsible for research and education, and named lawyer Luigi Berlinguer, the former rector of Siena University, to head it.

Berlinguer is no stranger to government service. He was science minister for 48 hours in 1993 in the cabinet of Carlo Azeglio Ciampi, before resigning with other ministers in a political protest over a move by Parliament to block investigations of corruption. The following year he left Siena University to pursue his political career. Now a prominent member of the Democratic Left Party, the leading party in the center-left Ulivo alliance, he had been among those widely tipped to be the new science minister.

A bigger surprise was the creation of the new superministry, formed by merging the Ministry of Universities and Science and Technological Research (MURST) and the education ministry. "Everyone was surprised [by the amalgamation]," Luciano Maiani, head of the National Institute for Nuclear Research, told *Science*, noting that the new ministry will have responsibilities ranging from "nursery school to Nobel laureate." But Umberto Colombo, who replaced Berlinguer as MURST minister in 1993, says the strong link this move will create between education and science should lead to an improvement in the appreciation of science—instilled from junior school up.

Science was a significant talking point during the election campaign. Romano Prodi, Italy's new prime minister and founder of the Ulivo alliance, gave it extensive space in his election manifesto, calling for an overhaul of the selection procedures for research funding, improvement in the country's poor record in international programs, increased university autonomy, more effective distribution of resources to Italy's depressed south, and improved technology transfer to industry.

But even with backing from the prime minister, Berlinguer has a tough task ahead. One of his first challenges will be to carry out Prodi's promise to increase spending on science. The treasury has pledged to reduce the national debt by about $6.5 billion by year's end, and politicians are already discussing a package of cuts worth $1 billion aimed at bodies including the National Research Council, the National Alternative Energies Agency, and the Italian Space Agency (ASI).

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Also high on Berlinguer's agenda will be reform of the university recruitment system, or *concorsi*, which have been widely discredited because of unworkable regulations and accusations of corruption (*Science*, 10 November 1995, p. 909). Berlinguer's immediate predecessor, physicist Giorgio Salvini, tried unsuccessfully to reform the system. In the end, he advertised 3500 associate professor positions using the old *concorsi* regulations—a move that angered many prominent academics—but this *concorsi* round has recently been suspended because of an alleged misapplication of the rules. As one of his last acts in office, Salvini appealed to the State Council to have the suspension annulled.

Another thorny issue will be reform of ASI. Established in 1988, ASI has a checkered history. Twice since 1993, its management was taken over by special commissioners appointed by MURST. Heavily in debt, ASI was criticized a few months ago by a review panel led by Nobel laureate Carlo Rubbia, which called for a reining in of spending on international projects and more emphasis on national programs. The current commissioner, Silvano Casini, is drawing up a 3-year research plan before his 1-year term ends in June. Casini has said he plans to accommodate some of the commission's suggestions, but will resist others because he strongly supports international projects such as the space station.

In his last days in office, Salvini lamented Italy's poor commitment to research, saying the country lacks "that strong belief in scientific research that induces a nation to make sacrifices to support it." Despite the election promises made by the Ulivo, Salvini says, "I don't yet see any strong conviction of the strategic importance of science and technological research." But others are welcoming Berlinguer's appointment. Although Berlinguer is not a scientist, he "is an expert in the problems of research and the universities," says Maiani. He will need that expertise—and more—in the months ahead.

**–Susan Biggin**

*Susan Biggin is a writer in Venice, Italy.*