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# NEWS

## In Brief

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### European global navigation satellite

**launches** The European Space Agency launched its first Galileo satellite on 28 December 2005. When fully deployed, the Galileo system will provide a European global navigation alternative to the U.S. global positioning system (GPS) and the Russian global navigation satellite system (Glonass).

The Galileo system will consist of 30 satellites (27 operational plus three active spare satellites) that are scheduled to be launched and fully operational by the end of 2008. The system will provide real-time positioning within one meter of accuracy and be fully interoperable with the U.S. and Russian systems. However, unlike GPS and Glonass, Galileo will be under civilian rather than military control.

The first Galileo satellite will test critical technologies for the system and characterize the radiation environment of the planned orbits for other Galileo satellites. A second demonstrator satellite will be launched in early 2006.

**Australian university proposes academic program changes** The University of Melbourne in Australia has adopted a 10-year plan to

create a U.S.-style of education where undergraduate university students would first have to complete a three-year general degree in science or the arts before being allowed to continue onto graduate or professional studies. Unlike in the United States, most Australian students are able to move from secondary school directly into professional studies.

A major change for Earth science students would be the replacement of the one-year Bachelor of Science Honours with a two-year Masters program. According to Janet Hergt, head of the university's School of Earth Sciences, the longer program could allow students more time to develop and complete research projects, and would provide them with a better understanding of Ph.D. studies.

Some academic staff members are concerned that this proposed undergraduate program could become just a 'service provider' to programs such as medicine, and remove senior students from key discipline areas, Hergt said. However, she noted that because Earth sciences currently receive scant attention in secondary education, the changes may benefit the discipline by introducing more students to the subject at the undergraduate level, which could result in increased interest.

### Ocean drilling vessel gets overhaul

After 20 years of ocean drilling, the research vessel *JOIDES Resolution* is getting a complete overhaul, including a new name, before it goes back into service in mid-2007.

A 50 percent increase in laboratory space and the addition of new instrumentation will allow scientists to analyze core samples onboard. Improvements to the drilling system and the ship's hull and machinery will increase both the rate at which cores can be obtained and their quality. Scientists and crew will also benefit from a renovation of the staterooms, which will be expanded to accommodate 23 additional people.

Scientists have completed more than 120 missions onboard the *JOIDES Resolution* through the Ocean Drilling Program and its successor, the international Integrated Ocean Drilling Program (IODP), for which the ship represents the U.S. contribution. When its makeover is complete, the ship will continue its work for the IODP.

"The enhanced vessel will greatly increase the efficiency and scope of drillship scientific operations, allowing IODP scientists to continue expanding our knowledge of the Earth," said Jamie Allan, IODP program director at the U.S. National Science Foundation, which is funding the ship's renovation.

—SARAH ZIELINSKI, Staff Writer

# MEETINGS

## The First Cluster and Double Star Symposium

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Cluster, a joint project between the European Space Agency (ESA) and NASA, is the first mission that is composed of four spacecraft flying in formation, and thus the first able to separate spatial and temporal features inside small-scale plasma structures within, and the boundaries between, many regions of the Earth's upper atmosphere (from 19,000–119,000 kilometers altitude).

During the past two years, the Cluster mission has been enhanced by the Double Star (DSP) mission, a magnetospheric mission composed of two satellites that is a joint project between the China National Space Administration (CNSA) and ESA. The orbits have been chosen so that interesting conjunctions occur frequently between Cluster and the two DSP satellites. Conducting coordinated studies using simultaneous Cluster and Double Star observations increases the overall scientific return from both missions.

The fifth anniversary of the Cluster mission was celebrated recently during the first Cluster and Double Star symposium. More than 160 scientists from China, Europe, Japan, Russia, and the United States gathered for this sym-

posium, which included 65 talks given in the course of five plenary sessions, and about 100 posters presented during two poster sessions.

### Dayside Magnetospheric Boundaries

A key scientific objective of the Cluster mission is to study the dayside magnetospheric regions and their boundaries, including the solar wind (at 1 AU), bow shock, magnetosheath, magnetopause, and polar cusp. The International Space Science Institute book, *Outer Magnetospheric Boundaries: Cluster Results* [Paschmann et al., 2005], presented at the beginning of the symposium, synthesizes the Cluster results obtained in these regions during the first few years of operation.

Among the symposium's highlights was the characterization of Short Large-Amplitude Magnetic structures (SLAMs) by Elizabeth Lucek (Imperial College, London). SLAMs are magnetic and plasma density enhancements that are believed to play an important role in the formation of the quasi-parallel bow shock. Using data from the four Cluster spacecraft for different inter-spacecraft distances all below 1000 km, the size of SLAMs was confirmed to be greater than 600 kilometers, with steep

magnetic gradients in their boundaries that are 100–150 kilometers thick.

In addition, cross-sections of SLAMs recorded by Cluster have shown that SLAMs are not constant but grow very fast, at a rate of about 25% per second, by drawing energy from energetic ions. As they grow, nonlinear effects enter into play, which compensate the growth by an energy transfer towards high frequency waves.

Another highlight was a statistical study by Jolene Pickett (University of Iowa, Iowa City) on the occurrence of electrostatic solitary waves (ESW) along the Cluster orbit. ESW are in the form of bipolar pulses (one positive peak and one negative peak) in the electric field parallel to the background magnetic field and typically last 2–5 milliseconds. These waves may play an important role, in particular, during magnetic reconnection by scattering and energizing electrons. Cluster has observed these waves at many locations, from the solar wind to the magnetosheath, magnetotail, and auroral zone—basically in all regions where the plasma is highly turbulent. Data from Cluster's four spacecraft enabled their size and speed to be determined and the first statistics about them to be compiled.

Cluster is an excellent tool to study the magnetopause, the external boundary of the magnetosphere. In the magnetopause, flux transfer events (FTEs) or plasma jets, formed by magnetic reconnection with the interplanetary magnetic field, are often observed (the amount of magnetic flux in a typical FTE is about 5 M Weber). An FTE is a transient and spatially confined type of magnetic reconnection.

tion. It can be considered as a crack in the Earth's magnetic shield (or magnetosphere) where solar material is able to enter. Data from Cluster's four spacecraft allow accurate determination of the geometry of the FTEs.

With the complementary observations by Double Star, Malcolm Dunlop (Rutherford Appleton Laboratory, Chilton, U.K.) and Zuyin Pu (Peking University, Beijing, China) showed that FTEs seem to be produced around the subsolar point (the closest point to the Sun on the magnetopause, usually located at  $\sim 10$  Earth radii) and then move away poleward and on the flanks of the magnetosphere when the interplanetary magnetic field is pointing southward. Furthermore, using the electron flows measured by the four Cluster spacecraft around one reconnection point, Patricia Reiff (Rice University, Houston, Texas) showed that the reconnection line was oscillating around the spacecraft and that electron demagnetization occurred close to the reconnection line, which is an important observational first to understand the microphysics of magnetic reconnection.

Another result combining Double Star and Cluster data is the simultaneous observations of electromagnetic waves at the low- and high-latitude magnetopause by Nicole Cornilleau-Wehrlin (Centre d'Etude des Environnements Terrestre et Planétaires (CETP), Vélizy, France). Models of propagation of these waves through the magneto-sheath and their capture on the magnetopause suggest that these waves could play an important role in magnetic reconnection. Her preliminary statistical study of 21 events shows that these waves near the subsolar point are almost always more intense than at high latitudes.

#### *Magnetotail and Nightside Auroral Region*

Another session concentrated on the nightside magnetosphere and highlighted the numerous new observations made by the Cluster mission, including substorm dynamics; multi-scale structure, dynamics and sources of the plasma sheet; studies of particle dynamics in the auroral region; and reconnection-related phenomena, including theory and simulation compared with data.

Cluster has made great progress in understanding the physics of the neutral sheet (current sheet at the center of the magnetotail), in particular the current structure, as well as the process of magnetic reconnection and particle acceleration. Rumi Nakamura (Space Research Institute/Austrian Academy of Science, Graz, Austria) presented an overview of achievements on magnetotail reconnection and plasma sheet flows, including studies by many of the symposium contributors.

In such studies, ground-based data are important to put Cluster observations in a global context. In particular, Steve Milan (University of Leicester, U.K.) and Olaf Amm (Finnish Meteorological Institute, Helsinki, Finland) presented Cluster observations in conjunction with ground-based data, revealing global dynamics of the magnetosphere and the resultant impact on the near-Earth region.

One of the highlights was the detailed analysis of the electrodynamic magnetosphere-ionosphere coupling of high-speed flows of plasma ( $> 300$  kilometers per second), carriers of decisive amounts of mass and energy from the magnetotail towards the Earth. Linking theory with new Cluster observations, Alain Roux (CETP) addressed the main competing theories of substorm initiation and discussed which one best matched recent Cluster observations.

In addition, the new capability of combined Cluster-Double Star observations was discussed, and the community is looking forward to exciting future opportunities available from such measurements.

#### *The Inner Magnetosphere*

The inner magnetospheric region had not been earlier considered as a main scientific target of the Cluster mission (see the Cluster mission proposal to ESA by *Haerendel et al.* [1982]). However, scientists on both sides of the Atlantic have often teamed up and achieved significant results, including the first localization of the source region of the nonthermal continuum (natural electromagnetic waves) by Pierrette Déréau (Laboratoire de Physique et Chimie de l'Environnement, Orléans, France) and coauthors; the first current density estimation in the ring current region (which extends radially from 2 to 9 Earth radii at the magnetic equator), presented by Claire Vallat (Centre d'Etude Spatiale des Rayonnements, Toulouse, France, and now at ESA/ESTEC (European Space Research and Technology Centre), Noordwijk, The Netherlands) and the first in situ estimation of the chorus emissions source region size by Ondrej Santolík (Charles University, Prague, Czech Republic) and coworkers. Chorus emissions are natural electromagnetic emissions (among the most intense in the outer magnetosphere) in the audio-frequency range.

The importance of chorus emissions was further emphasized by Richard Horne (British Antarctic Survey, Cambridge, U.K.) and coworkers. On the basis of coordinated ground-based measurements with Cluster data, they presented evidence of the significant role of these emissions in the acceleration of electrons to very high energies (several millions of electron volts) in the Van Allen radiation belts. These new results contradict the long-established theory that acceleration is accomplished by radial diffusion. [*Horne et al.*, 2005].

#### *Cluster Active Archive*

The Cluster Active Archive (CAA), a compilation of data taken from this mission, was widely presented and discussed in the meeting. All Cluster high-resolution data are in the process of being put online and made available to the worldwide scientific community without any restriction through the CAA (<http://caa.estec.esa.int/>). The system is being finalized and will become fully operational on 1 February 2006. Until 2010, the CAA will be populated with new data as soon as the data products have

been validated by the principal investigator teams, and feedback from the users will be incorporated into the archive data sets.

#### *Future Magnetospheric Missions*

A special session on future magnetospheric missions was held on the last day of the symposium. Representatives from China, Europe, Japan, Russia, and the United States presented their plans, which demonstrated the willingness of the scientific community to look ahead to future challenges. Worldwide, multi-spacecraft and formation flying are becoming standard characteristics of future missions, such as the NASA Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission with five spacecraft (launch, October 2006); CNSA Kuafu solar-magnetospheric mission with three spacecraft (launch, 2012); NASA Magnetospheric MultiScale (MMS) mission with four spacecraft (launch, 2013); and the ESA CrossScale project (potential collaboration with the Japan Aerospace Exploration Agency) with 10–12 spacecraft (launch foreseen from 2015 onward).

In this respect, Cluster and Double Star—as well as the ESA/NASA Solar and Heliospheric observatory (SOHO), a key mission to understand the Sun-Earth connected system—are successfully paving the way to all these future promising missions. “It is a good time to be a magnetospheric physicist,” James Slavin from NASA concluded at the meeting.

The Cluster and Double Star symposium: 5<sup>th</sup> anniversary of Cluster in Space was held on 19–23 September 2005 at the European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands.

The symposium proceedings will be published in early 2006 in ESA Special Publication ESA SP-598. Most of the talks can be found at <http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=37919>

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