German Aerospace Center

Searching for dark matter and antimatter

26 April 2011

Space shuttle Endeavour will deliver the Alpha Magnetic Spectrometer to the International Space Station

The Alpha Magnetic Spectrometer (AMS) will be located outside the International Space Station (ISS) and will use its various detectors to seek cosmic radiation in space. On 29 April 2011, at 21:47 CET (19:47 UTC), the AMS will be launched on board the space shuttle Endeavour from Cape Canaveral (Florida), en route to the ISS. The project, supported by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), will involve 500 scientists from 16 countries. The main scientific target is to find evidence for the presence of dark matter and antimatter. "The AMS experiment will provide the first opportunity to include astrophysics in the scientific applications of the ISS," said DLR Executive Board Chairman Johann-Dietrich Wörner.

Weighing almost seven tons and four metres high, the AMS uses a powerful magnet to direct charged particles of cosmic radiation through its detectors and then image them like a large camera. "The AMS is an instrument of a magnitude that we would normally only operate here on Earth," explained German project leader Stefan Schael of RWTH Aachen University (Rheinisch-Westfälische Technische Hochschule Aachen). Radiation undergoes a transformation as it encounters Earth’s atmosphere and does not reach the surface in its original form. This is why, at the surface of the Earth, only the decay products of space radiation can be detected. "The great challenge was to design a precision instrument that could withstand a shuttle launch," continued the project leader. "Normally, high accuracy, great sensitivity and the robustness required to survive a shuttle launch are mutually exclusive." The particle tracker, the heart of the instrument, can measure the trajectory of the particles with an accuracy of down to 10 microns, or about one-tenth the diameter of a human hair.

The researchers carried out an initial test in 1998. At that time, AMS-01, a test model of the current AMS, was carried into space on board the space shuttle Discovery and spent ten days measuring space radiation during the mission. One of the main challenges was to develop a magnet whose interaction with Earth's magnetic field would not affect the control of the space shuttle or the space station. Over 100 million charged cosmic particles were detected. Researchers were able to use this prototype to demonstrate how cosmic radiation is distributed in the vicinity of Earth. "With this mission we successfully demonstrated that AMS-02 would work."

Measuring 2000 particles per second

The main objective of the mission with AMS-02 is to contribute to solving the mysteries of dark matter and antimatter. "Our present-day knowledge of physics can only explain four percent of the composition of our universe; the remaining 96 percent, which has been called 'dark matter' and 'dark energy', we know virtually nothing about," explained Schael. Currently, science assumes that dark matter consists of new elementary particles that ensure, for example, that our Sun orbits the centre of the Milky Way on a stable path. "We can only determine the validity of this theory by finding evidence for the existence of dark matter." The AMS will also search for antimatter in space with an unprecedented sensitivity. According to Schael, this is one of the most important issues in physics at present. The current hypothesis in astrophysics states that, after the Big Bang, identical amounts of matter and antimatter were created. But no antimatter has been discovered in space yet. "If the AMS were to detect an anti-carbon nucleus, for example, it would indicate that the universe is in fact symmetrical, and that a spatial separation between matter and antimatter took place after the Big Bang."

The AMS detectors will 'see' 2000 particles per second as they fly through the experiment outside the ISS. The experiment will be able to determine, not just the energy, but also the mass and electrical charge of these particles, which are, for example, evidence of the remnants of massive supernovae. "With the AMS, we are creating what is essentially a kind of photograph of this particle flux using all the detectors." The AMS is designed to operate on the ISS for several decades, enabling cosmic radiation to be analysed over a complete solar cycle, during which the Sun’s magnetic field changes every 11 years. A number of subsystems are employed on the AMS. In Germany, the Institute of Physics at RWTH Aachen University and the Institute of Experimental Nuclear Physics at the Karlsruhe Institute of Technology (Karlsruher Institut für Technologie; KIT) are responsible for the Transition Radiation Detector, components of the particle tracker and a lateral particle shield.

Initial tests after the shuttle launch

Two hours after the launch of Endeavour, the researchers will switch the instrument on in the shuttle's payload bay and perform an initial functional test. Once at the ISS, the AMS will be removed from the shuttle payload bay using the shuttle's robotic arm, transferred to the ISS robotic arm, and then docked to the space station. Measurements of cosmic radiation will begin shortly after installation. A German research team in the United States will then operate and monitor the instrument around the clock, seven days a week, in three shifts. "Our research is only beginning," said Schael. "But it is already certain that with the AMS, we will learn a great deal about the composition of cosmic radiation, and thus also about the makeup of our galaxy."

About the project

German researchers and advanced German technology are playing a substantial role in this international project, which is being supported by the Space Administration at the German Aerospace Center (DLR) with funds from the German Federal Ministry of Economics and Technology (Bundesministerium für Wirtschaft und Technologie; BMWi).

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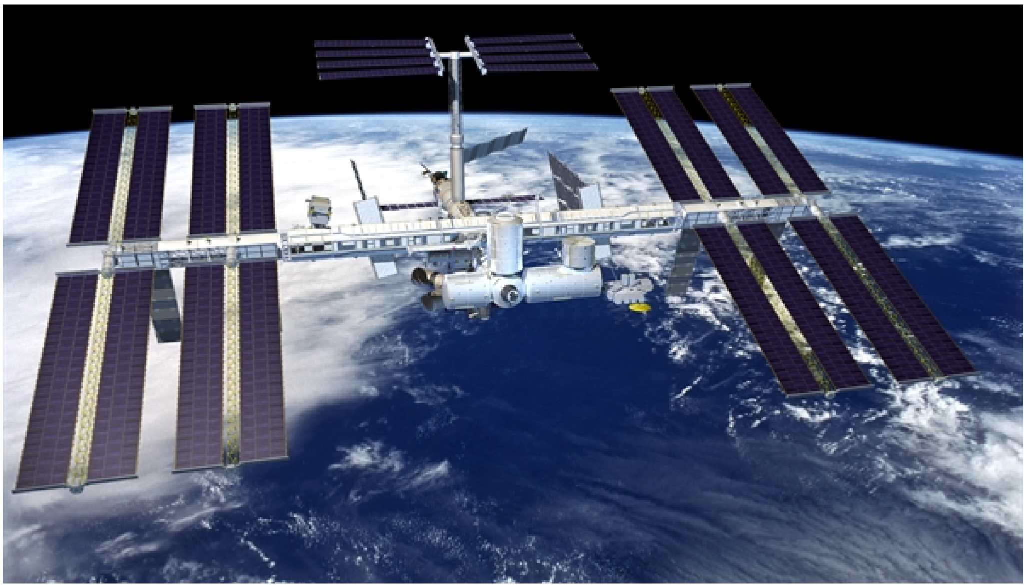
The Alpha Magnetic Spectrometer (AMS) will be installed on the ISS. In this artist's impression, AMS is visible to the right of the solar arrays on the left-hand side



The Alpha Magnetic Spectrometer (AMS) will be docked outside the International Space Station (ISS) and will use its various detectors to investigate cosmic radiation in space. The project, supported by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), will involve 500 scientists from 16 countries. The main scientific goal is to find evidence for the presence of dark matter and antimatter. In this artist's impression, AMS is visible behind the main truss, to the right of the solar arrays on the left-hand side.

Credit: NASA.

Preparations for loading the AMS instrument

The Alpha Magnetic Spectrometer (AMS) weighs almost seven tons and is four metres high. It uses a powerful magnet to guide charged particles of cosmic radiation through the detectors and then image them like a large camera.

Credit: NASA.

AMS instrument in the payload bay of the shuttle

Once at the International Space Station (ISS), the Alpha Magnetic Spectrometer (AMS) will be removed from the shuttle payload bay using the shuttle’s robotic arm, transferred to the ISS robotic arm, and then docked to the space station. Measurements of cosmic radiation will begin shortly after installation. A German research team in the United States will then operate and monitor the instrument around the clock, seven days a week, in three shifts.

Credit: Michele Famiglietti/AMS Collaboration.
