Goddard building instrument to study reconnection

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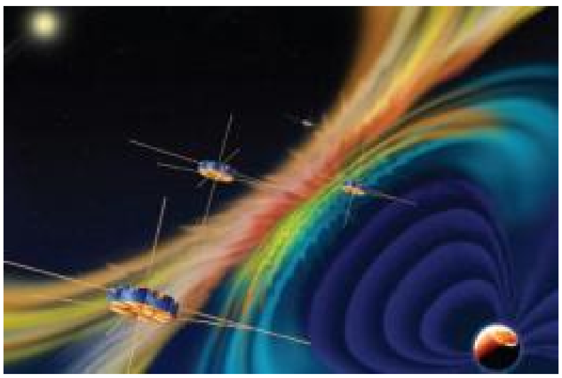

This is an artist's rendition of MMS as it sweeps through a magnetic reconnection event caused when the solar wind meets Earth's magnetic fields. Credit: SWRI

Whether it's a giant solar flare or a beautiful green-blue aurora, just about everything interesting in space weather happens due to a phenomenon called magnetic reconnection. Reconnection occurs when magnetic field lines cross and create a burst of energy. These bursts can be so big they're measured in megatons of TNT.

Several spacecraft have already sent back tantalizing data when they happened to witness a magnetic reconnection event in Earth's magnetosphere. However, there are no spacecraft currently dedicated to the study of this phenomenon.

All this will change in 2014 when NASA launches the Magnetospheric Multiscale (MMS) mission, a fleet of four identical spacecraft that will focus exclusively on this dynamic magnetic system that stretches from the sun to Earth and beyond.

At NASA's Goddard Space Flight Center in Greenbelt, Md., a team of scientists and engineers are working on a crucial element of the MMS instrument suite: the Fast Plasma Instrument (FPI). Some 100 times faster than any previous similar instrument, the FPI will collect a full sky map of data at the rate of 30 times per second – a necessary speed given that MMS will only travel through the reconnection site for under a second.

"Imagine flying by a tiny object on an airplane very rapidly," says Craig Pollock, the Co-Investigator for FPI at Goddard. "You want to capture a good picture of it, but you don't get to just walk around it and take your time snapping photos from different angles. You have to grab a quick shot as you're passing. That's the challenge."

Previous spacecraft, such as Cluster and THEMIS have helped narrow down the regions near Earth where magnetic reconnection happens. The solar wind streams towards Earth until it hits our planet's magnetic field, says Tom Moore, the project scientist for MMS at Goddard. "The solar wind comes flying in and the terrestrial stuff is like molasses – slow, cold and reluctant to do whatever the solar wind wants. So there is a contest of wills whenever the two fields connect up via reconnection."

That's what happens on the sun side of Earth. On the other side, the night side, magnetic reconnection in Earth's magnetic tail causes a geometry change in the shape of the field lines. Portions of the magnetic field get disconnected from the rest of the tail and shoot away from Earth.

The orbit for MMS will be tailored to hit these spots of magnetic reconnection on a regular basis. The first year and a half will be spent in the day side and the last six months in the night side. In the case of both day- and night-side reconnection, the changing magnetic fields also send the local ionized gas, or plasma, off with a great push. Measuring that plasma – a concrete, physical entity unlike the more abstract magnetic fields themselves – is one way to learn more about what's happening in that process.

"Right now the state of reconnection knowledge is simply that we know it's going on," says Moore. "One of the fundamental questions is to figure out what controls the process – the little stuff deep inside or the larger, external, boundary conditions. Some conditions produce a small burst of energy and sometimes, during what we think are the same external conditions, there's a huge burst of energy. That might be explained if the reconnection event depended crucially on what's going on deep inside, in an area we've never been able to see before."

The FPI instrument will measure the plasma in these small regions using electron and ion spectrometers. In order to capture as much as possible in the second-long journey through a magnetic reconnection site, each detector will be made of two spectrometers whose field of view is separated by 45 degrees, each of which can scan through a 45-degree arc for a larger panorama. There will be four dual electron spectrometers and four dual ion spectrometers onboard each MMS spacecraft. In combination, the ion spectrometers will produce a three-dimensional picture of the ion plasma every 150 milliseconds, while the electron spectrometers will do the same for the electrons every 30 milliseconds.

Not only is this approach an improvement of 100 times over previous plasma data collection, it's an advancement in terms of instrument building. For those doing the math: there are four plus four instruments plus one data processing unit on each of four spacecraft, which equates to 32 sensors and four data processing units, 36 boxes total.

"That's a huge number," says Pollock. "We're used to delivering one box, or occasionally two or three."

These instruments are, in turn, just part of the 100 instruments being built for MMS, each tailored to measure various electric and magnetic signals in space. The production is made even more challenging, says Karen Halterman, the program manager for MMS who oversees all pre-launch activities of the mission, because the entire spacecraft must be created to exacting standards. "You can't have a satellite that produces its own large electromagnetic signature when you're trying to precisely measure electromagnetism outside the satellite," she says. "We can't even use standard metal tools to build the hundreds of pieces in each satellite since they will add magnetic signatures into spacecraft."

The Southwest Research Institute in San Antonio, who designed the original instrument suite, is overseeing all the instruments for MMS, which are being built all over the country and globe—including in Japan. A Japanese company called Meisei has been contracted to build the ion spectrometers for the FPI.

"In the middle of a huge catastrophe," says Pollock, "the (Japanese) response has been remarkable and admirable. They have their problems, not least of which is rolling blackouts when some of the upcoming tests will require achieving vacuums that need several days of continuous electricity. We came up with a lot of contingency plans, but it turns out they don't need much help."

The Japanese instruments are still on track. The engineering test unit of the ion spectrometers is scheduled to arrive at Goddard -- after testing is completed at Japan's Institute of Space and Astronautical Science and NASA's Marshall Space Flight Center in Huntsville, Ala. -- early this summer. Indeed, the first FPI instrument for the first MMS spacecraft is due to arrive at the Southwest Research Institute in March of 2012.

Naturally, it's a busy time. The FPI team is finalizing the hardware and making sure all the parts pass a variety of standard tests, from ensuring the instrument won't vibrate apart during launch to making sure they still function properly when placed next to the electromagnetic signals streaming out from other instruments.

"What MMS is looking for is not something visible," says Halterman. "If you have a mission to study the sun or Jupiter, you can look at a picture and see the sun or Jupiter. Magnetic reconnection is a fundamental physics process. It happens on stars, on the sun, all over the universe, but it's much harder to get a deep understanding of it. FPI and the rest of the MMS instrument suite, with their great improvement in speed and resolution, are going to help change that."

More information: mms.gsfc.nasa.gov/

Provided by NASA's Goddard Space Flight Center

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