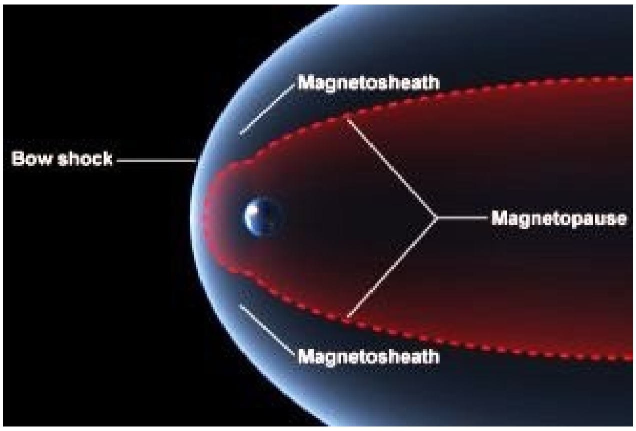
Scientists discover a new type of magnetic event

Space scientists recently uncovered a new type of magnetic event in the near-Earth environment. The new event happens just outside the outer boundary of Earth's magnetosphere – the sphere around Earth within which our world's magnetic field is the dominant field – in a region called the magnetosheath. Scientists using an innovative technique to squeeze extra information out of existing data learned that a process known as magnetic reconnection takes place in the magnetosheath. They reported their new discovery in a study in the peer-reviewed journal Nature on May 9, 2018.



Earth moving through space, with parts of its Magnetosphere and Magneto Sheath labelled

Before you shake your head and move on, consider this. The famous Halloween Storms of the year 2003 weren't ordinary rain storms, but geomagnetic storms high in Earth's atmosphere, triggered by massive solar flares erupting on the Sun, which had sent X-rays zooming through our solar system. **Along with the flares, the Sun expelled giant clouds of solar material, called coronal mass ejections, or CMEs. The CMEs slammed into Earth's magnetic field and pushed material and energy in toward Earth, creating the Halloween Storms, which caused brilliant auroras that could be seen as far south as Texas.** The 2003 solar storms also interfered with GPS signals and radio communications, and caused the Federal Aviation Administration to issue their first-ever warning to airlines to avoid excess radiation by flying at low altitudes.

Every step leading to these intense storms – the flare, the CME, the transfer of energy from the CME to Earth's magnetosphere – was ultimately driven by the catalyst of magnetic reconnection.

So you see magnetic reconnection is one of the most important processes in outer space, which is why scientists want to learn as much about it as they can. The new discovery found magnetic reconnection where it's never been seen before — in turbulent plasma.

Plasma is a form of matter in which electrons wander freely among the nuclei of atoms. It's been called a fourth state of matter, the other three being solid, liquid and gas. **Tai Phan** in the Space Sciences Laboratory at the University of California, Berkeley, and lead author on the paper, commented:

> *In the plasma universe, there are two important phenomena: magnetic reconnection and turbulence. This discovery bridges these two processes.*
> *In a turbulent magnetic environment, magnetic field lines become scrambled. As the field lines cross, intense electric currents (shown here as bright regions) form and eventually trigger magnetic reconnection (indicated by a flash), which is an explosive event that releases magnetic energy accumulated in the current layers and ejects high-speed bi-directional jets of electrons.*

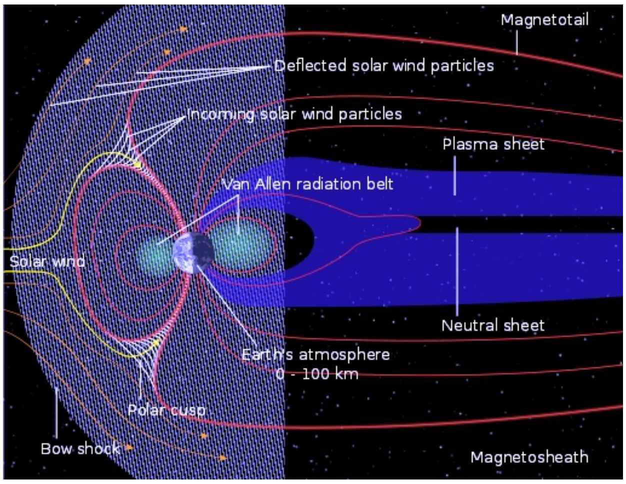
Scientists have seen magnetic reconnection many times in Earth's magnetosphere, but usually under calm conditions. **The new event – found in data from NASA's Magnetospheric Multiscale Mission, or MMS – was in the magnetosheath, where the solar wind is extremely turbulent**. Previously scientists didn't know if reconnection could occur there, as the plasma is highly chaotic in that region. MMS found it does, but on scales smaller than previous spacecraft could probe. Compared to standard reconnection, in which broad jets of ions stream out from the site of reconnection, turbulent reconnection ejects narrow jets of electrons only a couple miles wide.

That is why MMS scientists had to design an instrument, the Fast Plasma Investigatior, to create a technique to interpolate the data — essentially allowing them to read between the lines and gather extra data points — in order to resolve the jets.

Amy Rager, a graduate student at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the scientist who developed the technique, said:

> *The key event of the paper happens in only 45 milliseconds. This would be one data point with the basic data. But instead we can get six to seven data points in that region with this method, allowing us to understand what is happening*.

Using this new method, the MMS scientists are hopeful they can comb back through existing datasets to find more of these events and potentially other unexpected discoveries as well.



Earth is surrounded by a protective magnetic environment — the magnetosphere — shown in blue on the picture above, which deflects a supersonic stream of charged particles from the Sun, known as the solar wind. As the particles flow around Earth's magnetosphere, it forms a highly turbulent boundary layer called the magnetosheath. **Scientists, like those involved with NASA's Magnetospheric Multiscale mission, are studying this turbulent region to help us learn more about our dynamic space environment.**

THE SCIENCE OF MAGNETIC RECONNECTION

Understanding vast systems in space requires understanding what's happening on widely different scales. Giant events such as massive solar flares can turn out to have tiny drivers such as magnetic reconnection. This little understood process can accelerate particles up to nearly the speed of light and can initiate giant eruptions from the Sun many times the size of Earth. **The effects of reconnection have been observed in space, but the actual reconnection process has so far only been observed in the laboratory.**

Reconnection occurs wherever charged gases, called plasma, are present. Plasma is rare on Earth, but it makes up 99% of the visible universe. Plasma fuels stars and fills the near vacuum of space. Plasmas behave unlike what we regularly experience on Earth because they travel with their own set of magnetic fields entrapped in the material. **Changing magnetic fields affect the way charged particles move and vice versa, so the net effect is a complex, constantly-adjusting system that is sensitive to minute variations.**

Scientists want to know exactly what conditions, what tipping points, trigger magnetic reconnection events. Much of what we currently know about the small-scale physics of magnetic reconnection comes from theoretical studies, computer models, and laboratory experiments. True understanding, however, requires observing magnetic reconnection up close – so MMS will take its measurements in Earth's own magnetosphere, an ideal natural laboratory in which reconnection can be observed under a wide range of conditions.

Orbiting Earth, the MMS craft will pass through known areas of magnetic reconnection. During its first phase it will travel through reconnection sites on the Sun side of Earth. Here the interplanetary magnetic field connects with Earth's magnetic field, transferring particles, momentum and energy to the magnetosphere via magnetic reconnection. During the second phase of its mission, MMS will observe reconnection on the night side of Earth, where that connected field flows around both sides of Earth to a second reconnection point in what's known as the magnetotail, where they then disconnect.

These reconnection sites are so thin, that MMS will fly through them in under a second -- but the MMS sensors have been built to be fast, operating at unprecedented speed. As the spacecraft fly through such a site, they will measure the magnetic and electric fields present as well as the movement of particles.

Armed with this data, scientists will have their first chance to watch magnetic reconnection from the inside, right as it is occurring. By focusing on the small-scale process, scientists open the door to understanding what happens on larger scales throughout the universe. It has been suggested that Earth's magnetotail might even cause "dust storms" on the Moon by creating a potential difference between the day side and the night side. It will improve our understanding of how this process works on the Sun, on other stars, throughout space -- and it will teach us more about geomagnetic storms, helping us safeguard our home planet Earth. AK, with EarthSky and Wikipedia Notes