The Tale of Magnetic Reconnection (A Poem)

by Paul Cassak, written June 2016 for the CEDAR/GEM Student Day

Sit down and relax, I trust there is no objection,
And I will tell you the tale of magnetic reconnection.

It's a strange but cool process that has caused much confusion,
Though it's important for space weather, astrophysics and fusion.

Motivated by Giovanelli while studying solar flares,
He found they occur where magnetic fields cancel in pairs.

A graduate student named Dungey played the role of the hero.
He figured out what happens where magnetic fields go to zero.

Ideally, field lines can't break through stretching or attrition
As a result of Alfven's frozen-in condition.

But Dungey, he made a shocking proclamation,
That field lines can break due to small-scale dissipation.

It was argued by Sweet that plasma jets result from the constriction,
Then Parker used MHD theory to make an analytic prediction.

His excitement was real because it was much faster than diffusion,
But it was too slow to explain flares, causing despair and confusion.

They were out of ideas, the community was a wreck,
Until the bright idea by an engineer named Petschek.

While long, thin, Sweet-Parker layers cause major roadblocks,
The outflow jets could be formed at slow shocks.

What the doctor had ordered, Petschek had served.
Reconnection was as fast as flares are observed.

But the tale is not over, for didn't you hear?
Dungey realized reconnection occurs at Earth's magnetosphere.

The solar wind brings in the interplanetary field,
Which reconnects with Earth's magnetic shield.

Dayside field lines move tailward where an energy reservoir forms.
Then reconnection in the tail releases it in geomagnetic storms.

Dungey realized the convection driven by reconnection would yield
Exactly the observed patterns in the ionospheric electric field.

Despite these successes, reconnection remained curious,
Many didn't believe it, it made Alfven furious.

Evidence was indirect, there was much uncertainty.
Until direct observations of jets by Paschmann with the satellite ISEE.

We've since gotten more data that we've been able to muster,
From Polar, Geotail, Double Star, THEMIS and Cluster.

Theoretical work has produced a ton that we can add to our courses,
Thanks in part to the increase in speed of supercomputing resources.

In situ observations are not easy to nab,
But now there's no doubt it occurs, we can even see it in the lab.

So our understanding of reconnection is doing quite good.
But there remain many things not sufficiently understood.

How energy is stored and what starts its release.
How fast it goes and what makes it cease.

And also the subject of many articles
Is how reconnection heats plasmas and accelerates particles.

And it remains unclear, for goodness sake,
What causes the dissipation allowing magnetic field lines to break.

Resistive MHD doesn't cut it, it has a great flaw,
Instead we need to consider generalized Ohm's law.

Though, by itself, it doesn't allow field lines to reconnect,
The GEM Challenge showed the importance of the Hall effect.

To determine the role of the electron pressure tensor,
We need a satellite with an incredibly fast sensor.

The most recent advance in our reconnection tale,
Is the development of Magnetospheric Multiscale.

Four satellites in formation with only a 10 kilometer separation,
Designed to measure reconnection dissipation.

It measures electron distributions 100 times as fast
As any mission had ever done in the past.

MMS has now measured crescent-shaped electron distributions,
With electrons from the sheath crossing to the magnetosphere to make a contribution.

MMS is gathering a wealth of great high resolution data,
So stay tuned for new results that will come around later.

Thanks for listening to the tale of magnetic reconnection,
But the story's not over - there are still open questions!