

What We Discovered

Aurora, and space weather, is driven by merging, not the solar wind electric field ...

And a formula for the merging rate

or

“Earth’s Magnetosphere Has a Heartbeat”

(“merging” connects the Earth’s magnetic field with the solar wind’s)

P. T. Newell, T. Sotirelis, K. Liou, and C.-I. Meng

The Johns Hopkins University Applied Physics Laboratory

F. J. Rich

Space Vehicles Directorate, Air Force Research Laboratory

Hanscom Air Force Base

What Drives the Aurora (and space weather...)?

Not “solar flares”, or coronal mass ejections.

There is aurora every day of the year, with tens or hundreds of gigawatts of power.

Since the mid 1970s, most calculations have assumed that the solar wind electric field is the driver.

Yet space scientists also feel merging between the solar wind’s magnetic field and the Earth’s magnetic field is key (though no formula existed to calculate rate)

What We Did

Ten characterizations of the magnetosphere were examined over multiyear periods (example: global auroral power)

Scores of coupling functions were tested (performance of 20 functions documented)

Our Data

(Mostly over 11 to 22 year periods)

5 Space-age indices:

Auroral power (NASA satellite called “Polar”),

Solar wind entry to upper atmosphere (US Air Force DMSP satellites)

Stretching of Earth’s magnetic tail (NOAA’s GOES-8 satellites and USAF DMSP satellites)

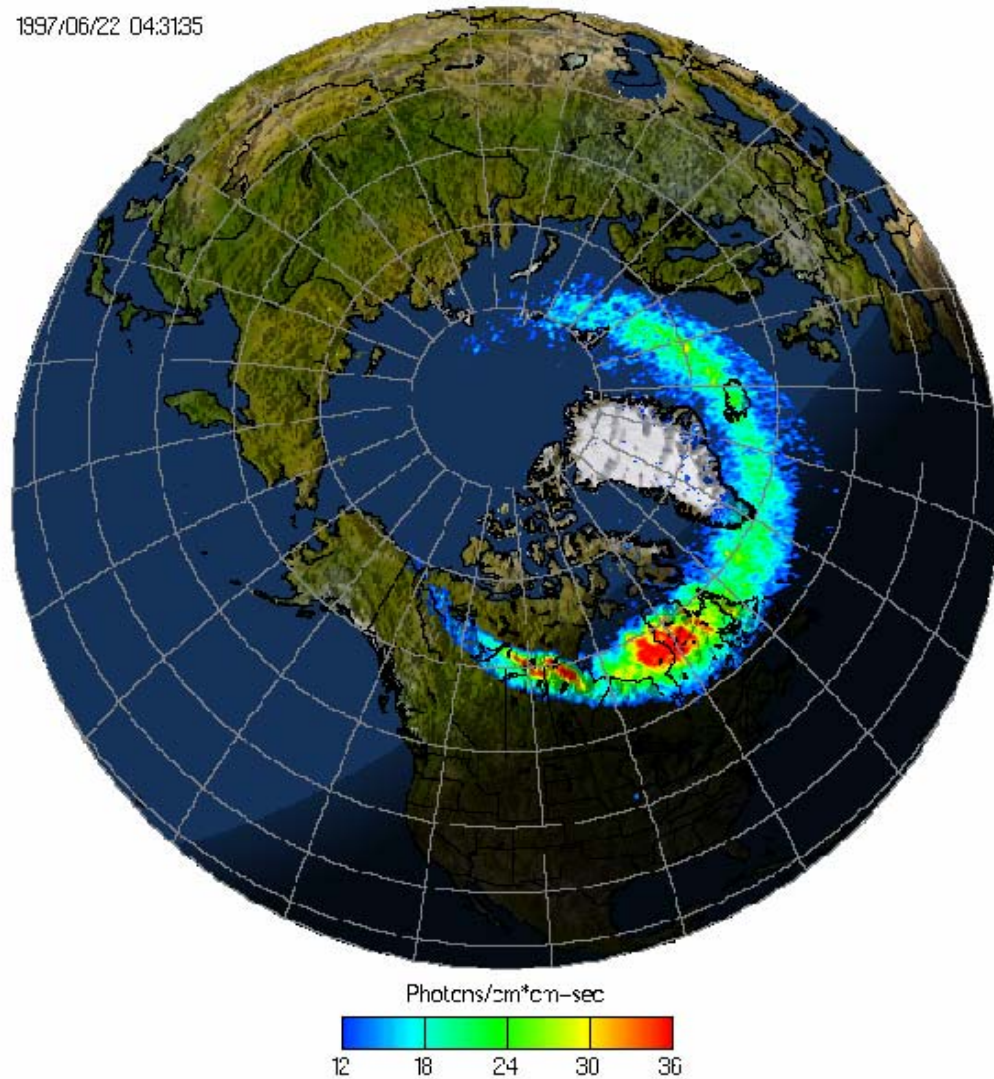
Polar cap flux from a world-wide radar chain (“SuperDARN”)

and

5 Traditional (ground-based magnetometer) indices

NASA Satellite “Polar” Images the Aurora Globally

1997/06/22 04:3135

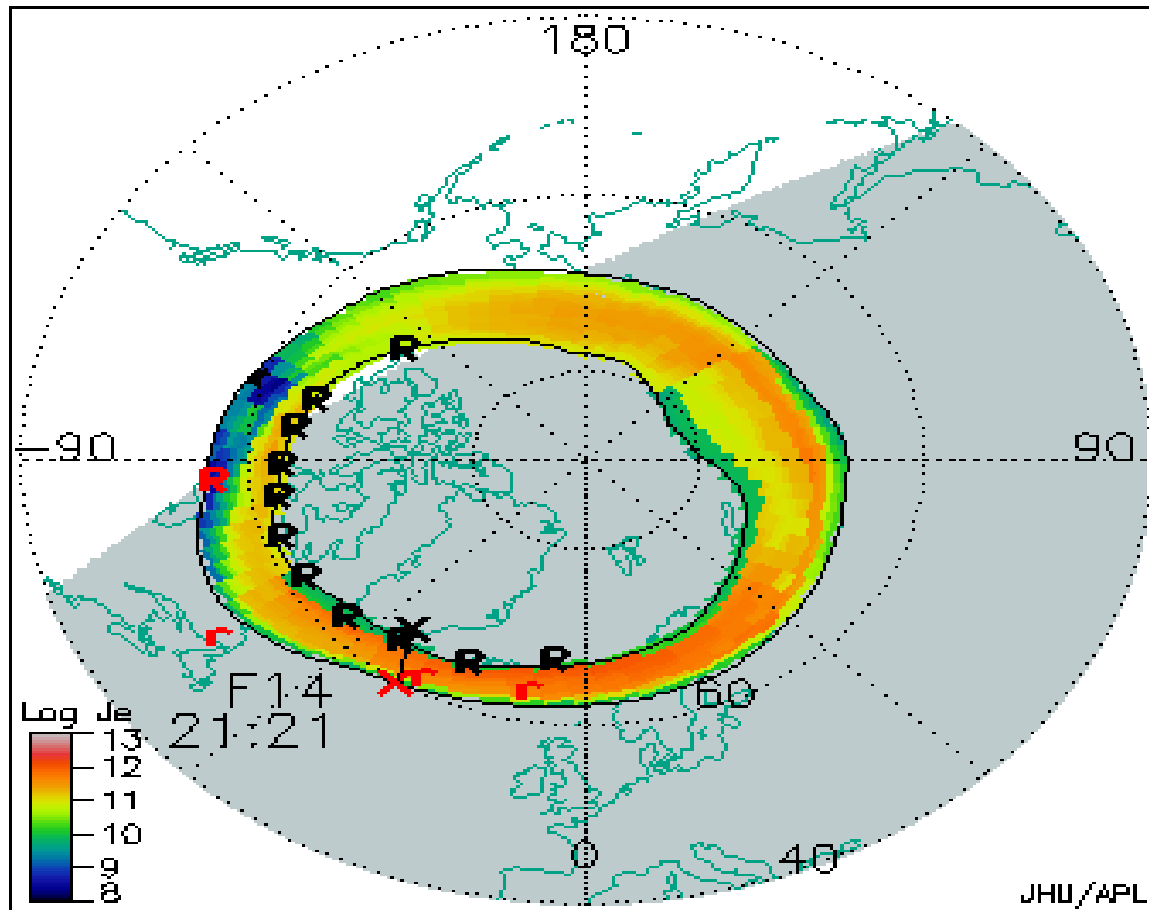


A Network of Radars Called “SuperDARN” Was Used to Find the Size of the Polar Cap

NORTH CAP

End Time 28 Jan 2003 – 21:59 UT

DMSP Satellite : F14



Equivalent Kp = 2.3

Flux = 738 MWb

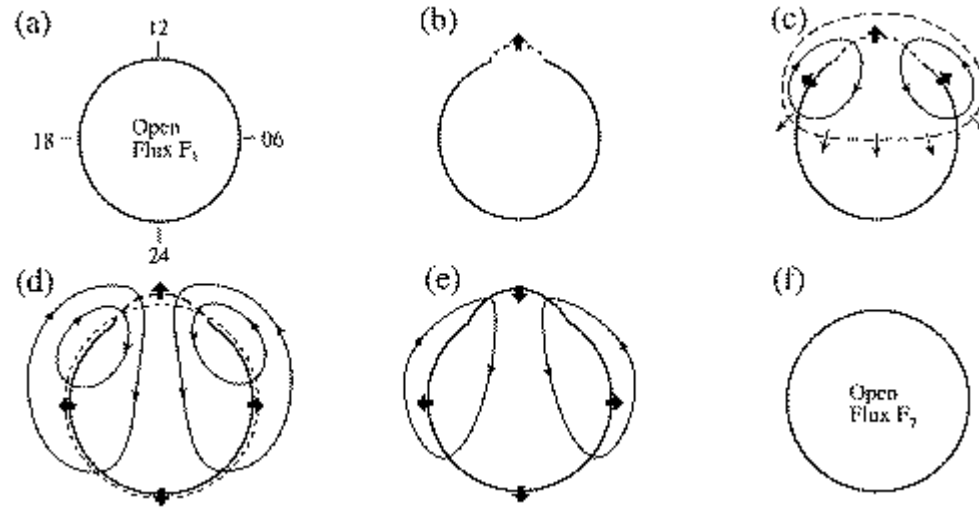
What We Found

- A single (new) function predicts best 9/10 (or all 10 depending on how one counts) data sets.
- The new function clearly is NOT the solar wind electric field
- The new function represents the rate of merging between the Earth's magnetic field and the solar wind's.

What Does It Mean

- The circulation of plasma and magnetic flux through near-Earth space is driven by merging (Siscoe-Cowley-Lockwood model).
- We have a formula for the global merging rate
- The magnetosphere is vast and diverse. Yet a wide variety of phenomena can be best predicted by single formula.

Siscoe-Cowley-Lockwood ("Heartbeat" model)



This model explains the circulation of plasma and flux through space, as not directly driven by the solar wind electric field, but rather by merging.

The Winning Function

$$d\Phi_{MP}/dt = v^{4/3} B_T^{2/3} \sin^{8/3}(\theta_c/2)$$

Compared to the solar wind electric field, the new function is:

Higher than linear in solar wind velocity

Sub-linear in the solar wind's magnetic field B_T

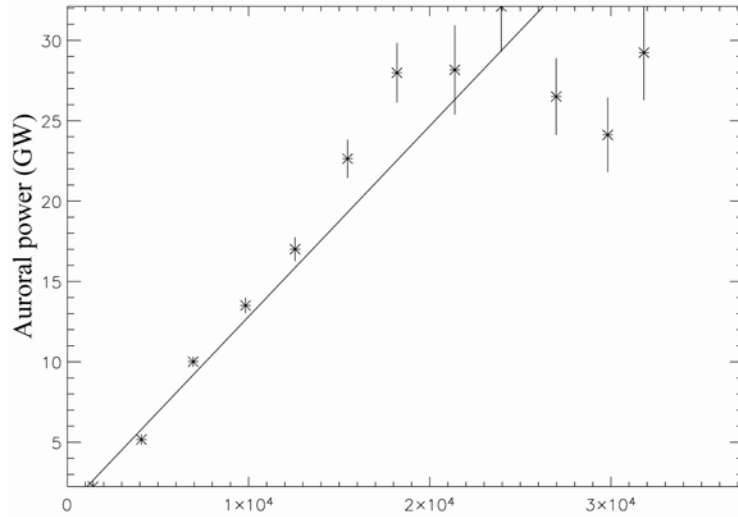
More at:

<http://sd-www.jhuapl.edu/Aurora>

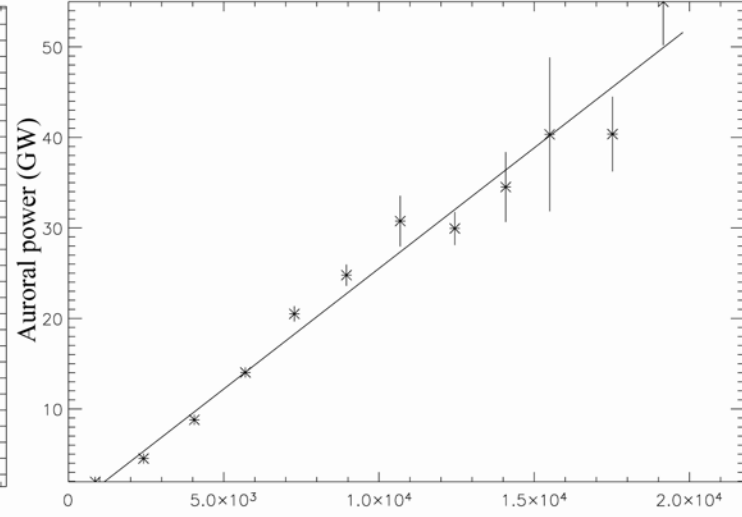
or google “Newell aurora”

(End of press conference presentation. Material that follows bears on answers to possible questions)

Auroral power versus Solar Wind Electric Field



Auroral Power vs Global Magnetic Merging Rate



When the solar wind electric field is used to predict auroral power (left), the calculations tend to break down at moderate to high levels. The new function (right) works over a wider range of conditions.

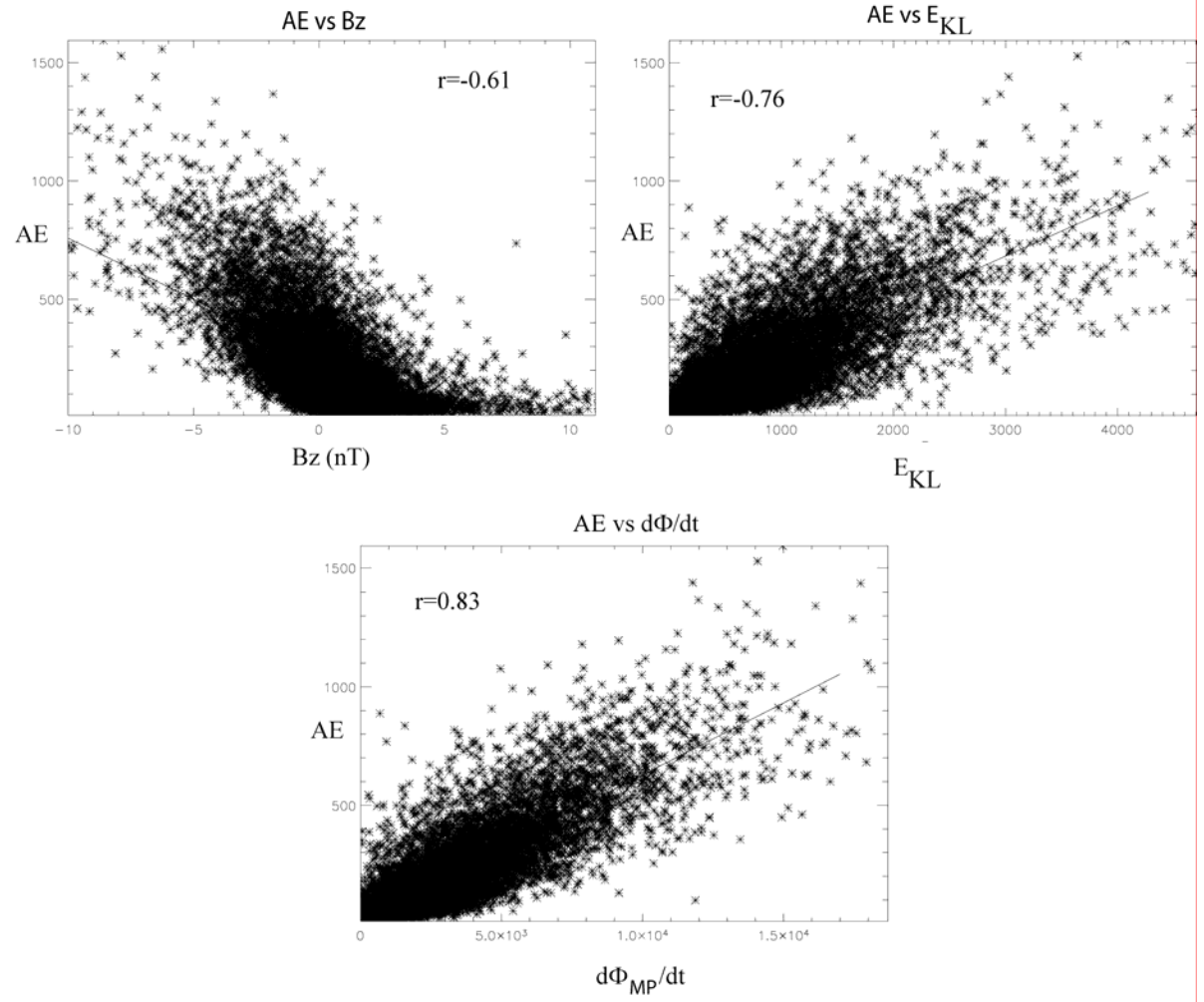


Figure 2. Scatter plots of AE versus Bz (top left), E_{KL} (top right) and $d\Phi_{MP}/dt$ (bottom).

ISEE-2 observations are consistent with our clock angle dependence

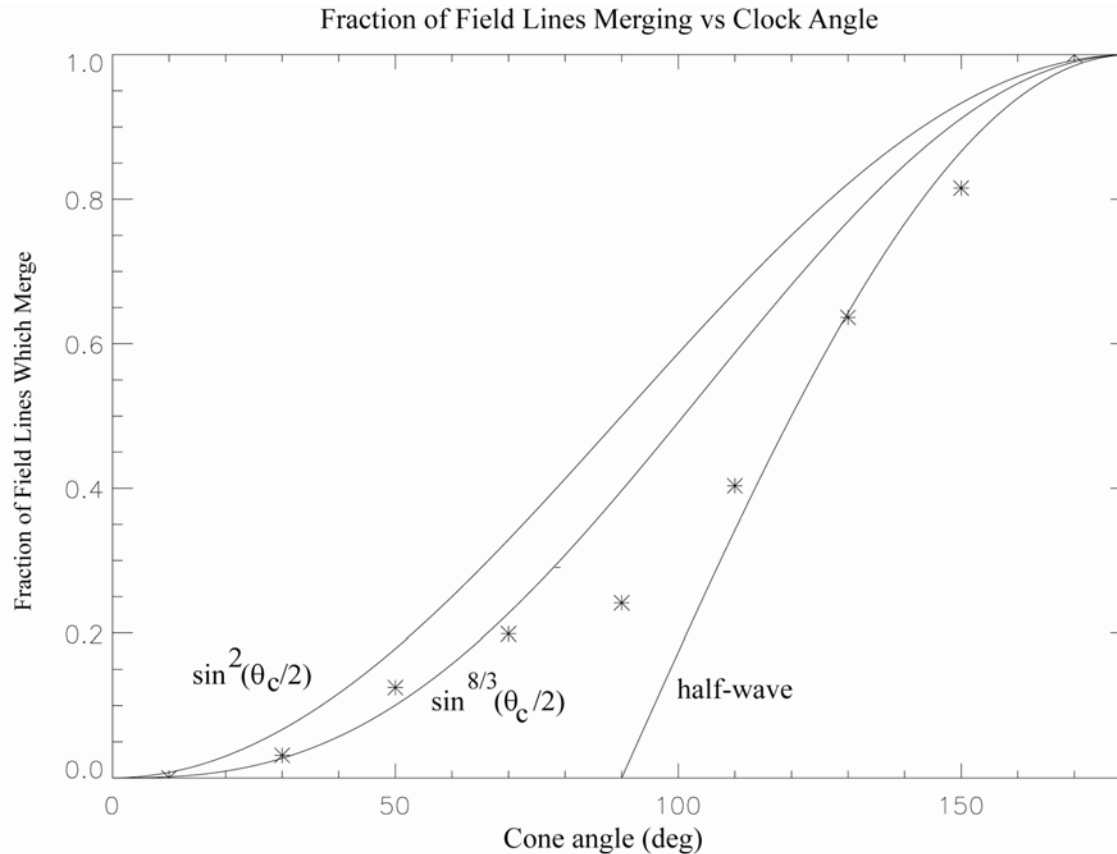


Figure 5. The merging rate for E_{KL} (left curve), half-wave rectifier (right) and $d\Phi_{MP}/dt$ (middle) Superposed ("*") is the merging rate from an ISEE-2 survey at the magnetopause.