Using Auroras to Investigate the Geospace Magnetic Topology

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The Earth's magnetic field is roughly a dipole out to about geostationary distance (6.6 Earth Radii or 42,000 km). The magnetic bottle created by the dipole field traps energetic electrons and protons, which circle around the Earth in addition to their bounce motion between the mirror points. In the direction away from the Sun (the "nightside"), interaction with the solar wind stretches the Earth's dipole field into a long magnetotail similar to that of cometary tails. However, though stretched, the magnetotail field is still topologically similar to the dipole field, and the trapped particles can only gain access to the atmosphere by leaking through the loss cone. The precipitation into the loss cone is what creates the auroral oval, which then is a visual representation of the magnetic bottle atmospheric end.

However, there are periods when the auroral oval topology splits into two, forming a large "theta" orientation. The "theta bar" is seen to grow from the nightside (lower left) toward the dayside (top right) until the polar cap within the oval is completely split into two. The theta bar then moves eastward and finally merges with the oval again. It is a longstanding question how this pattern is connected with the magnetotail, as simple topological argument would suggest similar splitting of the magnetotail.

We investigate the theta aurora phenomenon by using a global MHD simulation to model the solar wind – magnetosphere – ionosphere system for the duration of the theta aurora. With the simulation, we can trace the field lines to map the locations of the theta aurora to the magnetotail to resolve the origin of the particles creating the unusual auroral shape. The model results are validated by comparing them with the global auroral satellite images.

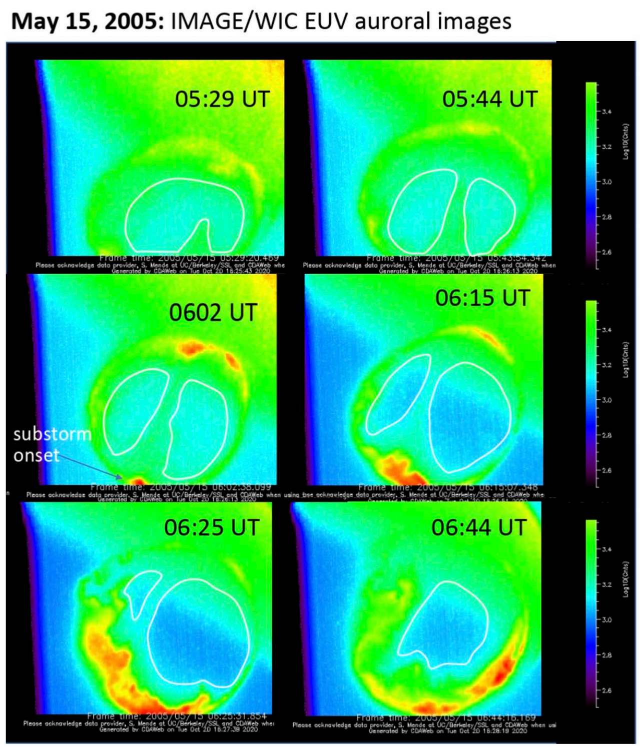

Figure 1 – IMAGE satellite ultraviolet (UV) images of the auroral oval on May 15, 2005. The auroral oval shows a theta configuation from 05:44 UT to 06:44 UT. The emission in the top right part of the images is dayglow and not part of the auroras.