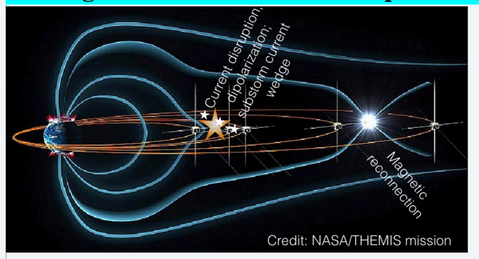
Corotating Magnetic Reconnection Site in Saturn's Magnetosphere

Zhonghua Yao[1], A. J. Coates[2], L. C. Ray[3], I. J. Rae[2], D. Grodent[1], G. Jones[2], M. K. Dougherty[4], C. J. Owen[2], R. L. Guo[5], W. R. Dunn[2], A. Radioti[1], Z. Y. Pu[6], G. R. Lewis[2], J. H. Waite[7] and J.-C. Gerard[1]

[1]Laboratoire de Physique Atmosphérique et Planétaire, STAR institute, Université de Liège, Liège, Belgium
[2]Mullard Space Science Laboratory, University College London, UK
[3]Department of Physics, Lancaster University, Lancaster, UK
[4]Faculty of Natural Sciences, Department of Physics, Imperial College, London, UK
[5]Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
[6]School of Earth and Space Sciences, Peking University, Beijing, China
[7]Southwest Research Institute, San Antonio, TX, United States

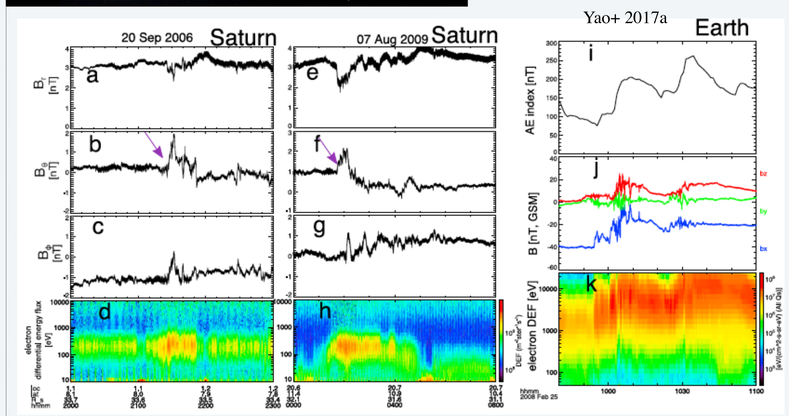
Abstract: Using measurements from the Cassini spacecraft in Saturn's magnetosphere, we propose a 3D physical picture of co-rotating reconnection site, which can only be driven by an internally generated source. Our results demonstrate that the co-rotating magnetic reconnection can drive an expansion of the current sheet in Saturn's magnetosphere, and consequently produce Fermi acceleration of electrons. This reconnection site lasted for longer than one Saturn's rotation period. The long-lasting and co-rotating natures of magnetic reconnection site at Saturn suggest fundamentally different roles of magnetic reconnection in driving magnetospheric dynamics (e.g., the auroral precipitation) from the Earth. Our co-rotating reconnection picture could also potentially shed light on the fast rotating magnetized plasma environments in the solar system and beyond.

Magnetic reconnection and dipolarization at Earth and Saturn

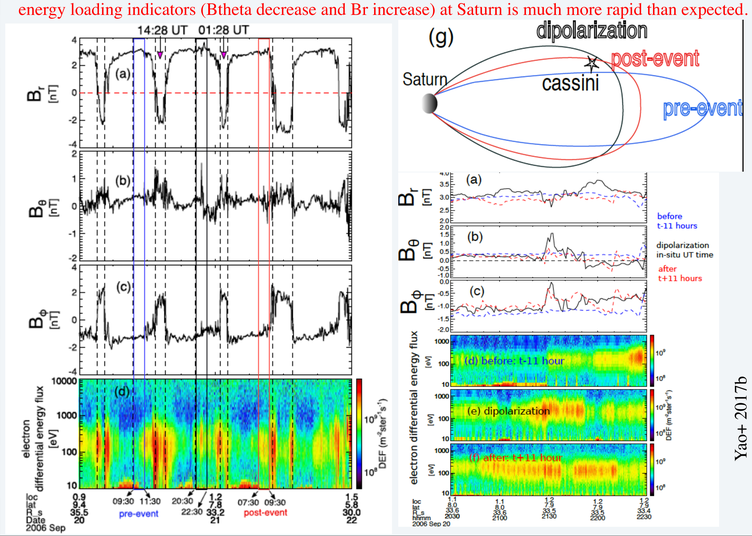


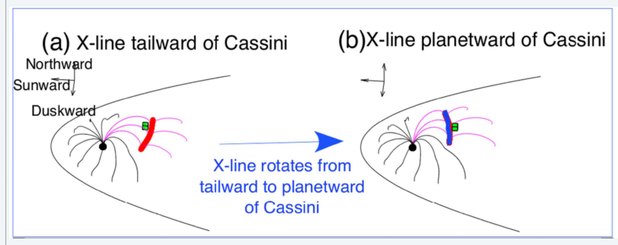
- ✓ **Substorm dipolarization** is caused by disruption of cross-tail currents, and formation of field-aligned currents (**10^6A**).
- ✓ Enhancement of Bz is wavy, which lasts for a few minutes, usually suggesting plasma instabilities (e.g., Lui+ 1991, *JGR*).
- ✓ **A change of magnetic geometry**

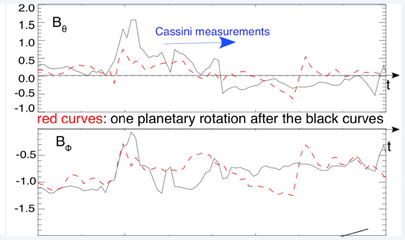
Note that 'dipolarization front' is a different process.



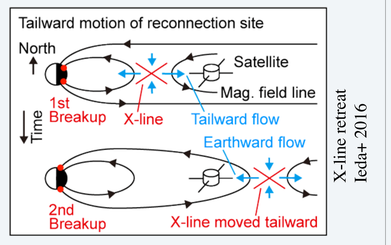
Similar Bz/Btheta enhancement, Bx/Br decrease and enhancement of electron flux, however, the succedent energy loading indicators (Btheta decrease and Br increase) at Saturn is much more rapid than expected.



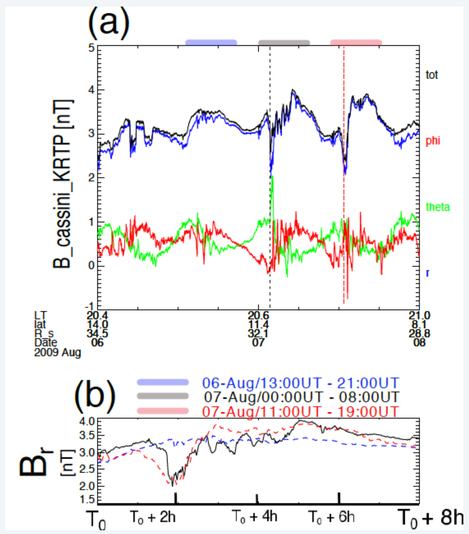


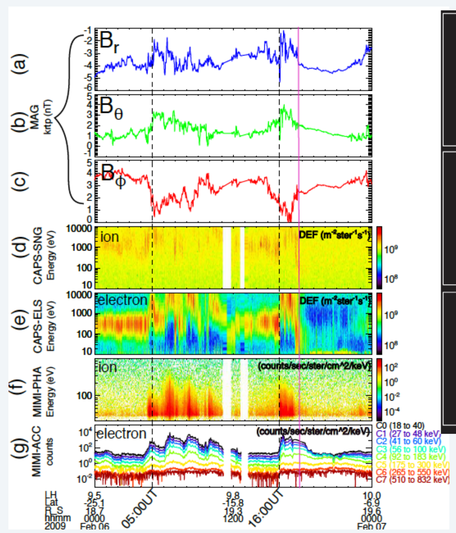


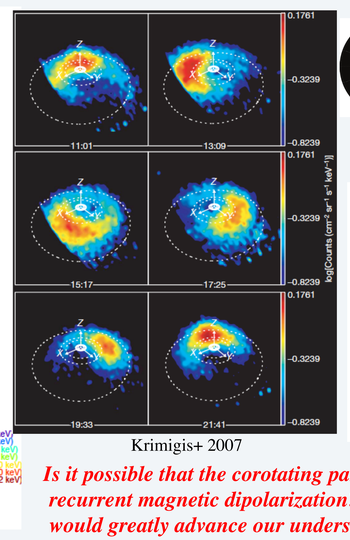
The repeat of magnetic structure cannot be fully explained by 2-D reconnection retreat picture



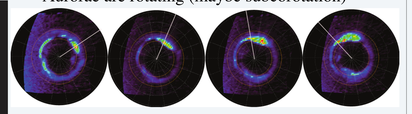
Recurrent dipolarization process at Saturn: what is the cause?



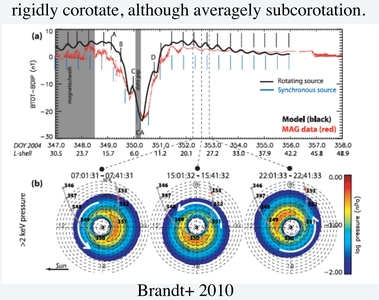




Aurorae are rotating (maybe subcorotation)



ENA enhanced sites are also rotating, could often rigidly corotate, although averagely subcorotation.



Is it possible that the corotating partial ring current could produce the recurrent magnetic dipolarization? Comparison between these datasets would greatly advance our understanding Saturn's magnetospheric dynamics.

Conclusions

1. With the measurements from Cassini-Huygens mission, we identified two types of dipolarization signatures, one of which is very similar to terrestrial substorm dipolarization. **However the following magnetic signature at Saturn is significantly different from the post-dipolarization signature at Earth.** We suggest that the sharp decrease of Btheta component is due to planetary rotation induced spatial variation, but not a consequence of terrestrial-like temporal evolution.
2. Following the recurrent Btheta bipolar signature, we proposed a rotating reconnection site picture at Saturn.
3. Recurrent dipolarzation events are identified at Saturn, which are associated with burst energetic particles. This signature cannot be explained by any existing theories that we are aware of, however is consistent with the corotation of reconnection site.
4. Previous measurements of plasma have shown that ion bulk flow usually subcorotate, it remains mysterious why reconnection site or dipolarization region could reoccur after one planetary rotation beyond 10 Rs.
5. It is unclear whether the recurrent dipolarization or reconnection site are related to planetary periodic oscillation (PPO).

ZY is also a Marie-Curie COFUND postdoctoral fellow at the University of Liege. Co-funded by the European Union.