Lightning and Energetic Radiation
Recent work at the University of Bergen

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Outline

- **ASIM**
  - Status, progress.
- **Data analysis**
  - RHESSI data search
  - Spark data analysis
- **Modeling**
  - RHESSI/Fermi comparison
  - Aircraft/balloon observation modeling
  - Lightning modeling
Lightning,
Sprites,
Blue jets,
Elves,
TGFs,
TGF electron beams,
...
Lightning

Video credit: Tom Warner
Runaway electron avalanche
Sprites

Video credit: Steve Cummer
Context

Lightning

- Thousands of deaths/year.
- Billions of USD damage.
- Not really understood.

Lightning as charge motion

- Large charge motion $\rightarrow$ sprites
- Fast charge motion $\rightarrow$ elves

Lightning as particle accelerator

- Up to 40 MeV? Up to 100 MeV?

Implications?
ASIM

MXGS
- Coded mask
- CZT low-energy
- BGO high-energy

MMIA
- Photometers
- Cameras

ISS/Columbus
- Nadir pointing
- Observe TGFs and lightning
ASIM exploded
ASIM status

- Passed PDR
- Now phase C
- Working on electronics, final design
- Expected launch “2015”
RHESSI data search

Re-analyze RHESSI data, lower threshold, careful calculations.

Get $\sim 2 \times$ more events, same WWLLN match rate.

Spark data analysis

- 2 MV Marx generator at TU/e.
- Search for runaway electrons.
- Understand x-ray statistics.
- Plastic scintillators / optical fibers.
- Various positions.
- ~ 900 sparks.

![Graph showing data points](chart.png)
See Carlson et al., European Geophysical Union Conference presentation (next week).
RHESSI/Fermi comparison

- Different dead-time, triggering.
- Different detection thresholds.
- ... compare detection rates.
- Constrain fluence distribution.
- → power law, $\lambda \sim 2.3$
- → RHESSI dead-time consistent.

Aircraft/balloon observation modeling

- Assume TGF-scale emission.
- Predict aircraft, balloon observations.
- Criteria for campaign design.
- Understand ADELE observations.

Hansen et al., upcoming.
Lightning modeling – TDFL

Electric field dominates behavior

\[
E(x, t) = \frac{1}{4\pi\varepsilon_0} \int d^3 x' \left\{ \frac{\hat{R}}{R^2} \left[ \rho(x', t') \right]_{\text{ret}} + \frac{\hat{R}}{cR} \left[ \frac{\partial \rho(x', t')}{\partial t} \right]_{\text{ret}} - \frac{1}{c^2R} \left[ \frac{\partial J(x', t')}{\partial t} \right]_{\text{ret}} \right\}
\]

Calculate E-field along channel, determine current. Currents determine charge evolution.

- Full time-domain evolution, \(< 1\ \mu\text{s to } > 100\ \text{ms}\) scale, stochastic extension, unconstrained geometry, adaptive time-stepping, corona sheath, channel property evolution.
- Many parameters (initial conditions, channel properties...)

[Diagram of lightning channel with arrows indicating electric field (E), current (I), charge (\(\Delta Q\)) and extension decision point]
TDFL movie

Carlson et al., upcoming.
Et cetera...

- Bremsstrahlung meeting
- Electron beam modeling
- RREA feedback modeling
- New RHESSI data / correlations with lightning
- ...
- Any other ideas? Collaborations?

Thanks!

The UiB TGF group:

Nikolai Østgaard (PI), Thomas Gjesteland, Ragnhild Hansen, Alexander Skeltved, Øystein Grondahl, and the ASIM engineering team.