The Wave Driver of Relativistic Microbursts Through Ground Observations

Emma Douma1, Craig J. Rodger1, Mark A. Clilverd2, Aaron T. Hendry3, Mark J. Engebretson4, and Marc R. Lessard5

1Department of Physics, University of Otago, Dunedin, New Zealand
2British Antarctic Survey (NERC), Cambridge, United Kingdom
3Now at Department of Space Physics, Institute for Atmospheric Physics, Prague, Czech Republic
4Department of Physics, Augsburg University, Minneapolis, Minnesota, USA
5Department of Physics, University of New Hampshire, Durham, New Hampshire, USA

Abstract: This paper presents a statistical analysis of relativistic microbursts, linking them to ground-observed EMIC waves and whistler mode chorus waves. The study involves the use of SAMPEX, VELOX, and Halley magnetometer data. The results show that microbursts are preceded by EMIC waves and occur when whistler mode chorus waves are active. The study also demonstrates the importance of relativistic microbursts in precipitating MeV electrons, affecting the polar atmosphere.

Introduction

Relativistic Microbursts:
- Precipitation of >1MeV electrons.
- Short duration, <1 second
- Occur in morning MLT region from L = 3 - 8.

Case Study Conjunctions Between SAMPEX and Halley

Case 1: Whistler Mode Chorus Wave
- 16 individual microbursts on 2 March 2005, beginning at 12:25:56 UT.
- Sunlight conditions at Halley.
- Increase in wave amplitude in the 1-4 kHz range of VELOX.
- Rounded shape identified as whistler mode chorus waves.
- There is no wave power in the Bz component of Halley magnetometer.
- No EMIC wave activity present.

Case 2: EMIC Wave
- 3 individual microbursts on 1 July 2005, beginning at 18:36:30 UT.
- Night conditions at Halley.
- Increase in wave amplitude in the 1-4 kHz range of VELOX.
- No whistler mode chorus wave activity present.
- Bursts of wave power in the Bz component of Halley magnetometer.
- Wave power is identified as Helium band IPDP EMIC waves.

Case 3: Whistler Mode Chorus and EMIC Waves
- 4 individual microbursts on 19 May 2005, beginning at 12:45:58 UT.
- Partial sunlight conditions at Halley.
- Increase in wave amplitude in the 1-4 kHz range of VELOX.
- Rounded shape identified as whistler mode chorus wave activity.
- Bursts of wave power in Bz component of Halley magnetometer.
- Wave power is identified as Hydrogen band EMIC waves.

Conclusions From Case Studies
- First evidence of EMIC waves associated with relativistic microbursts.
- Case studies suggest that either whistler mode chorus waves or EMIC waves can drive the scattering resulting in relativistic microbursts.
- Potential for EMIC waves to act as secondary driver of relativistic microbursts.

Supersposed Epoch Analysis of Halley Wave Activity

Whistler Mode Chorus Wave Activity
- Supersposed 1 min average wave amplitude in 2 kHz channel of VELOX.
- Ionospheric attenuation differences between Summer and Winter.
- 242 relativistic microburst events during Halley Winter.
- 170 relativistic microburst events during Halley Summer.
- Statistically significant increase in 2 kHz wave amplitude associated with relativistic microburst events.

EMIC Wave Activity
- Supersposed mean wave power in 0.1-0.8 Hz frequency range of magnetometer.
- Usable data for 295 relativistic microburst events.
- 75 EMIC linked relativistic microbursts.
- 127 relativistic microbursts linked to broadband noise.
- EMIC linked microbursts, broadband noise linked microbursts and remaining microburst events all show increase in the mean wave power around the time of relativistic microbursts.

Conclusions From Statistical Analysis
- Increase in VLF wave amplitude, likely result of whistler mode chorus waves, associated with relativistic microbursts.
- Burst of ULF wave power associated with microburst events dominated by broadband noise (not EMIC waves) which is not expected to scatter electrons.
- Whistler mode chorus waves suggested primary driver of relativistic microbursts.

Additional References: