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Using Data From the Lamp Rocket to Investigate Microbursts and Pulsating Aurora

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Background

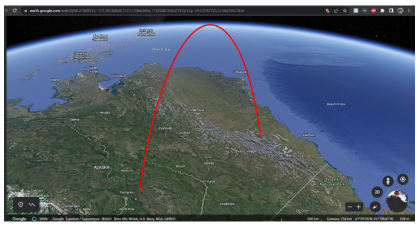
-The term "microburst" was coined by Anderson and Milton (1964), where it was used to describe X-ray observations seen by balloons in the auroral zone and was typically written as "auroral microburst".

-First simultaneous observations of microbursts in both X-ray and electron precipitation was reported by Blake et al. (1966), from correlations between balloon-borne 391.4 nm and precipitating electrons with energies > 400 keV.

-Imhof et al. (1992) related microbursts to radiation belt dynamics -- beginning a shift in focus on microbursts from their connection to auroral processes to their connection to Earth's radiation belts. By the year 2000, the connection to aurora had nearly vanished and the term "auroral microburst" had virtually disappeared from the literature.

Mission Strategy

-Launch from Poker Flat over a pulsating aurora event.



Instrument	Institution	Sensor type	Range	Heritage
EPLAS	UNH	2D electron distributions	10 eV - 20 keV	SERSIO, SCIFER2, ROPA, CASCADES, MICA, RENU2
ESST	GSFC	Solid State Telescope	20-600 keV	VAP, JUNO, MMS, ROPA, WIPP
HEP	ISAS/JAXA	SSSD (electrons)	~700 keV to 2 MeV	ARASE satellite
PIPs	Dartmouth	Thermal Ion RPA	T_I and drift velocities	MICA, Isinglass
ERPA	UNH	Thermal Electron RPA	0.06 - 3 eV	SERSIO, SCIFER2, ROPA, ACES, MICA, RENU2
MAG	UNH	3-axis fluxgate	±60,000 nT	SIERRA, SERSIO, ROPA, MICA, RENU2
AIC	Tohoku Univ	Auroral imager	670 ±15 nm	potential contribution not mission critical

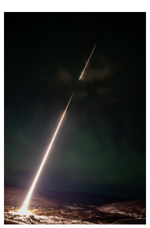
-Payload included *extensive measurements of precipitating electrons in order to characterize the complete precipitating electron energy spectrum.*

-Additional instruments included to measure **E** and **B** fields and electron temperatures.

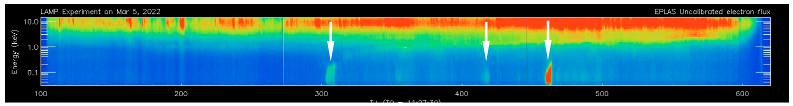
-Auroral cameras (2) included to image the aurora from onboard the payload, supported by a Despun Platform.

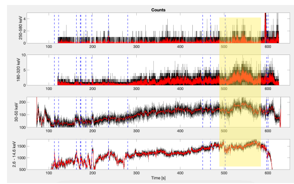
-Ground-based imagers provided a critical role, with 7 cameras acquiring data from 3 sites (Venetie, Poker Flat and Fort Yukon).

-Other ground-based instruments included PFISR radar, riometers and magnetometers.

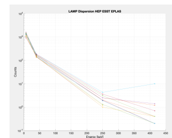


LAMP electrons: high- and low-energy populations

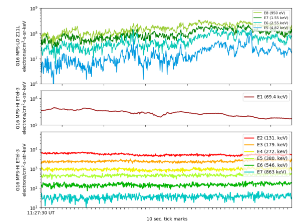




Precipitating electron fluxes were measured using 3 instruments: EPLAS (10 eV-15 keV), ESST (20-600 keV and HEP (700 keV - 2 MeV).
- All three instruments showed the same basic signature where electron fluxes increased during the latter part of the flight.
- Early in the flight, electron signatures were well correlated. Late in the flight, the higher energies show a broad peak in occurrence, while the lower energies were depleted (see yellow highlight).



Plot showing the net electron distribution function, using data from all 3 instruments.
- The energy range for these electrons spans more than 2 orders of magnitude.
- Whether (or how) bursts of electrons from the different instruments is correlated is not yet clear.



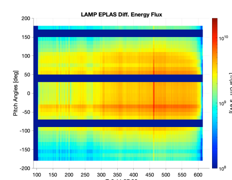
Plots showing GOES 17 observations of electron precipitation at ~137° W longitude. Energies in the top panel are comparable to the EPLAS data. Energies in the middle a lower panels are comparable to the HSST and HEP instruments.

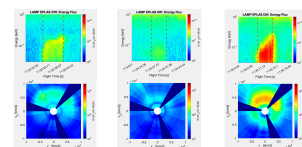
The science team is currently working on comparing these data to those measured on LAMP.

LAMP low-energy electron populations

The three white arrows in the plot at the top of the page highlight examples of low-energy bursts observed by LAMP, but note that there are several fainter bursts. The connection between these bursts to the more energetic precipitation is not understood. We highlight some important points and describe them to the right and below.

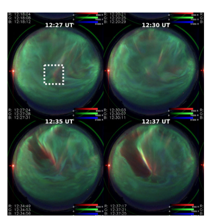
We can make some statements at this point:
- A magnetic signature of 5-10 nT was observed with the 3rd burst.
- Their pitch angle distributions are isotropic, minus the loss cone. This is similar to the higher energy electrons.
- The bursts are not correlated with any aspects of the precipitating electrons, but may be occurring in conjunction with structuring in the patches.
- There are no clear signatures of electron heating that would occur with precipitating soft electrons.
- Soft electrons can establish ambipolar fields, driven by an ambient heated population. An ambipolar field would support ion upflow, which has recently been observed in pulsating aurora.



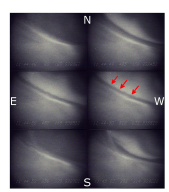


The plot above (left) shows electron pitch angle distributions versus time-of-flight. A direction of 0° is one that is parallel to **B** (downward). The main populations is seen to be fairly uniform for angles within ~90°.

The three plots on the right show the details of the bursts. The top panels show precipitation up to 1 keV, with increasing energy during the bursts. The bottom panels show the distribution functions which, like the main population, is isotropic minus the loss cone.

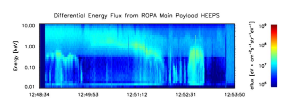


Godbole NH, et al (2022) show observations of ion upflow in pulsating aurora, based on allsky camera and PFISR data. PFISR data indicate that Te and Ne increase and an ambipolar electric field is established. The upflow was correlated with red aurora (soft electron precipitation), perhaps the type of bursts shown above.

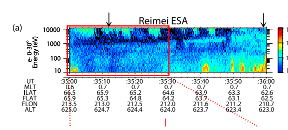


Fritz, B. A. et al, (2015) show observations of black aurora and curls (vorticity) beginning at 1144 UT, during the ROPA rocket launch (images separated by ~1 s).

-Patch in the NW corner is separated from the diffuse aurora by a black arc and pulsates with a period on the order of a few seconds.
- Curl structures appear while the pulsating patch is active. Red arrows indicate three crests of the structure.

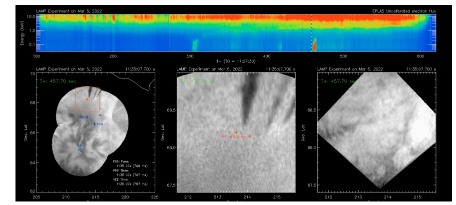


From Jones, S. L. et al, (2009), ROPA observations of low-energy electron populations. Similar bursts were observed by the ROPA rocket in 2007

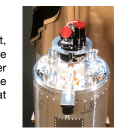


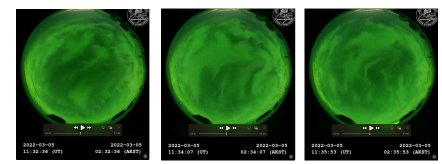
REMEI observations of low-energy inverted-V distributions. These bursts again look similar to LAMP, but have inverted-V structures. From Nishiyama et al, 2011.

Auroral overview



Auroral images were acquired throughout the flight, with ground-based cameras located at downrange sites (Fort Yukon and Venetie) as well as at Poker Flat. Two cameras were also included onboard the payload, supported by a despun platform that stabilized the cameras on the spinning payload.





The images above were acquired using the DASC color camera at Poker Flat. For the majority of the flight, the payload was well north of these features, though the activity appeared to span the entire trajectory. The frames above correspond to the three bursts discussed above.

Summary

The presentation shows results from the LAMP (Loss through Auroral Microburst Pulsations) rocket, focusing on aspects of the electron data. There appear to be two populations in the data; the relationship between them is not understood.

- The main electron population (i.e., higher energies) spans more than 2 orders of magnitude in energy.
- Trends in fluxes from the 3 instruments were well correlated early in the flight. Later in the flight, the higher energies show a broad peak in occurrence, while the lower energies were depleted.
- Details regarding the relationship between the low- and high-energy bursts are still being studied.

Lower energy electron bursts were also observed, noting the following details.
- Their pitch angle distributions are isotropic, minus a loss cone, similar to the energetic population.
- There is a 5-10 nT magnetic pertubation associated with the most intense event.
- There are no clear signatures of electron heating.
- The bursts are likely related to smaller-scale features in pulsating aurora, perhaps ion upflow.

References

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