(Form11-1)

Occurrence of red-green low latitude aurora during large geomagnetic disturbances: Case studies

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Personal Note

Fortunate to have been associated with the Institute of Space Earth Environment (ISEE) at Nagoya University, Japan, under the supervision of Prof. Kazuo Shiokawa when I was awarded the prestigious SCOSTEP Visiting Scholarship to conduct a research project during October-December 2023.

Space Physics Context

Auroras are observed and studied using ground and space based instruments over decades. Space based observations reveal the large-scale evolution of auroras, but the fine structures are not evident. On the other hand, fine structures are clear from the ground observations but are sometimes limited by the cloudy skies and moonlight. Auroras at mid-low latitudes are observed over centuries (e.g., Loomis, 1861; Chapman, 1957; Tinsley et al., 1986; Rassoul et al., 1992; Miyaoka et al., 1990; Shiokawa et al., 1994). During high geomagnetic activity, auroral oval expands to lower latitudes. The important driving mechanisms for low latitude auroras are broadband electrons and stable auroral red (SAR) arcs. Observations have shown that these auroras have red to green emission ratio greater than 10, and the dominant red emissions are caused by the de-excitation of atomic oxygen mainly in the top side ionosphere. The north looking all sky cameras from Japan usually observe the red aurora during the main phase of geomagnetic storms and with storm-time substorm activity. The electron precipitations over a wide energy range, 30 eV – 30 KeV were reported from earlier DMSP observations during such substorms (Shiokawa et al, 1997). Stable Auroral Red (SAR) arcs formed in sub auroral latitudes also cause low latitude auroras, which are during the recovery phase (RP) of geomagnetic storms. SAR arcs last more than 10 hours and are caused by low energy electron precipitation (<10 eV). SAR arcs occur due to the Coulomb collision between energetic ring current ions and the electrons in the plasmasphere causing precipitation to sub-auroral latitudes.

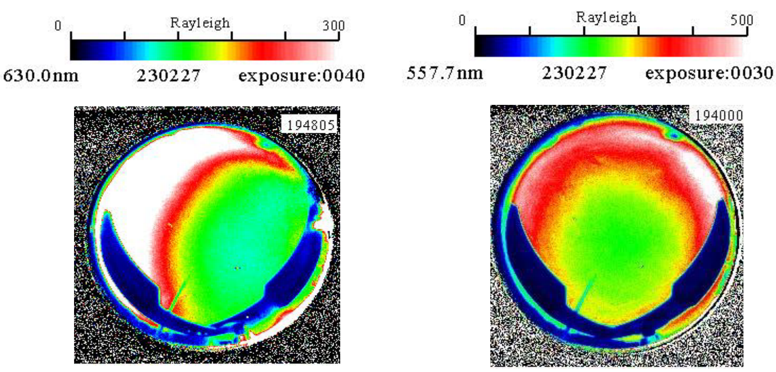

Fig 1: Red and green aurora from Rikubetsu at ~19:45 UT on 27 February 2023

Only a limited number of low latitude auroras were reported, mostly red emissions and at high levels of solar activity. Recently, unusual red and green simultaneous auroral emissions of comparable intensities are observed from Rikubetsu, Japan (43.5 ^{0} N magnetic latitude) during the rising phase of solar cycle 25. One such red-green aurora of ~300-400R are observed during the geomagnetic storms on 27 February 2023. Detailed investigations of these events are made to understand their dynamics.

Data Analysis and Methodology

The primary observations are based on All sky camera and photometer measurements from Rikubetsu, Japan (43.5 N, 143.8 E, magnetic latitude) which is a contributing station in the OMTI network (Shiokawa et al., 1999, 2000). The electron precipitation, density and temperature data are from DMSP, NOAA/POES METOP and SWARM satellites.

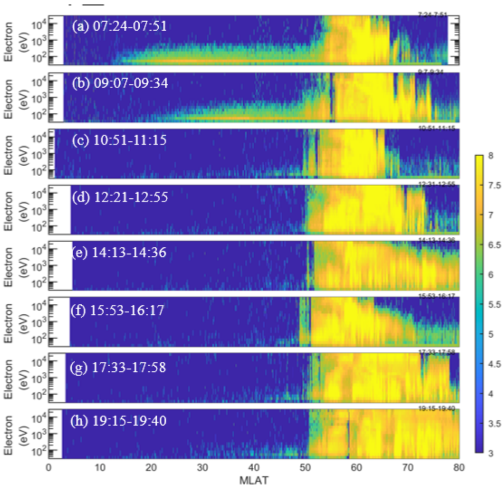

Fig 2: DMSP F18 shows the auroral expansion

Results

Low Latitude Aurora on 27 February 2023

This aurora (Fig. 1) is seen (16:00-20:00 UT) during the RP of a storm with prior SymHMin of -160 nT at 12 UT. The solar wind velocity increases to ~850 km/s and IMF Bz to -20 nT indicating the possibility of strong magnetosphere-ionosphere coupling. DMSP F18 satellite close to the time and location of the aurora recorded the auroral oval expansion to $\sim48^0$ mag. lat. (Fig. 2). The temperature increased with the corresponding decrease in density indicating the development of SAR arcs.

Stay at ISEE, Nagoya University

My time in Nagoya was very pleasnat and perfect both for research and living with sports and cultural activities. The weekly discussions with Prof. Shiokawa and his lectures on plasma dynamics to the master students gave me insights into the way of delivering knowledge, sharing ideas, and mentoring. His association significantly increased my understanding of the bahaviour of plasma in the solar wind, magnetosphere, and ionosphere.

Though it was a short stay, I could carry a bag full of treasured memories ranging from the futsal matches every week with professors and students to the calm brainstorming discussions. Fondly acknowledging and thanking Dr. Kazuo Shiokawa, Dr. Yuichi Otsuka, Dr. Claudia Martinez, Dr. Shreedevi P. R, Dr. Abadi Prayitno, Mr. Rei Sugimura, Mr. Gomi Masaki, Ms. Miho Sugiyama, and Ms. Naoko Kashimura for all the academic and administrative assistance.