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Statistical analysis of auroral structures related to the plasma instability based on ground optical observations

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Auroral complex shapes are formed due to the connection of the ionosphere and magnetosphere by geomagnetic field lines which project disturbance of the magnetosphere onto the ionosphere through auroral particles. Thus, study of the auroral dynamics is important in considering the disturbance of the magnetosphere. Shiokawa et al. [JGR, 2010] reported observations of small-scale finger-like auroral structures which appeared on the west side of auroral patches, using a high-resolution narrow field-of-view CCD camera at Gillam (geomagnetic latitude: 65.5 N), Canada. At the recovery phase of substorm in the night side, these structures appeared when the speed of the patches moving to the east was slowed down, due to the macroscopic Rayleigh-Taylor type instability in the magnetosphere. However, statistical characteristics of this phenomenon have not been investigated yet. In this study, based on observations by an all-sky imager at Tromso (magnetic latitude: 67.1 N), Norway from January 2009 to November 2012, we made statistical analysis of the occurrence conditions of 19 events of auroral structures that seem to be driven by pressure-driven plasma instability. We found fourteen large-scale finger-like structures which developed from auroral arcs and six small-scale finger-like structures which appeared in auroral patches. We investigated MLT dependence of the start time of these finger-like structures, their relationship with auroral substorms, scale sizes, eastward drift speeds, development speeds, and so on. The large- scale structures were seen from midnight to dawn and small-scale structures were seen at dawn mainly. Large-scale structures tend to appear at the beginning of substorms' recovery phase and small-scale structures tend to occur at the late recovery phase of substorms. The scale sizes of these large and small structures are larger than the gyro radius of the ions in the magnetospheric equatorial plane, indicating that the finger-like structures are caused by MHD instabilities. The eastward propagation speeds are slower than the typical midnight auroral drift speed. This fact indicates that the low-energy plasma may be source of the structures. However, this consideration may contradict with the idea that the high-energy particles lead to the pressure-driven instability.

Keywords: aurora, pressure-driven plasma instability, ground optical observation