**Author Comment to Referee 2**

The model of spiral auroras presented may explain basic scenario for the clockwise rotation of auroras. Such cases can be found at the edge of auroral sheet referred to as “Peeling-off” and in a clockwise rotation of the flame trains referred to as “Flame-structure formation” [Oguti, 1975, 2010]. Shear layers presented in Figure 3 are a type of large-scale flame-structures.

References

Oguti, T., Metamorphoses of aurora, Memoirs of NIPR, series A, 12, 1975.

Oguti, T.: Introduction to auroral physics (in Japanese), Edited by Solar-Terrestrial Environment Laboratory, Nagoya University, 2010.

In general, auroral sheet may be produced in the pre-existing background arc (Figures C, D, and E).

In this case, auroral sheet (Orange) was newly produced in the pre-existing background auroral arc (Blue) as is shown in Figure C. Electric fields (E, open arrows) emerged in the background arc, while the new sheet rotated clockwise. As a result, drifts (V, Red) occurred in the background arc, poleward in the eastern half of the arc and equatorward in the western half of the arc. Background arc was split.

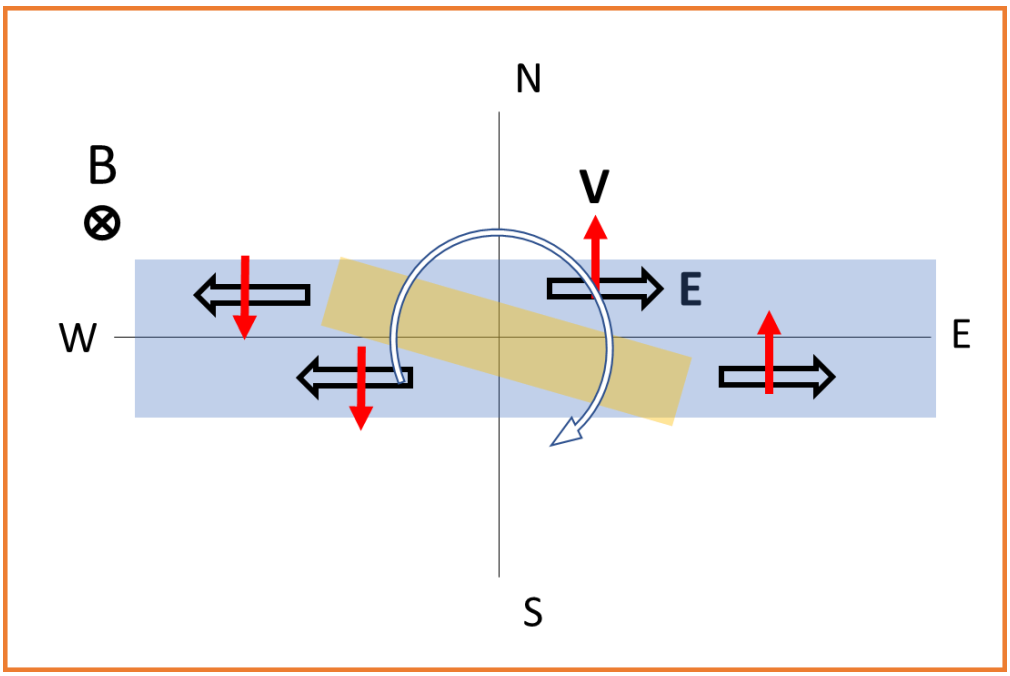
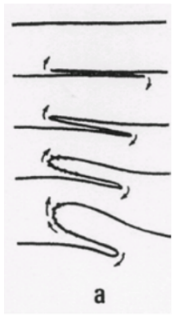



Figure C

Progression of the splitting arc may cause “pleat unfolding” as shown in Figure D. Folded structures are finally released by rotating the auroral sheet by $\pi$ radians (Figure E). Sequence of the auroral sheet deformations from split of background arc (formation of pleat), pleat unfolding, and its release are shown in the left-hand side of Figures D and E [adapted from Oguti, 1975].




Oguti, 1975

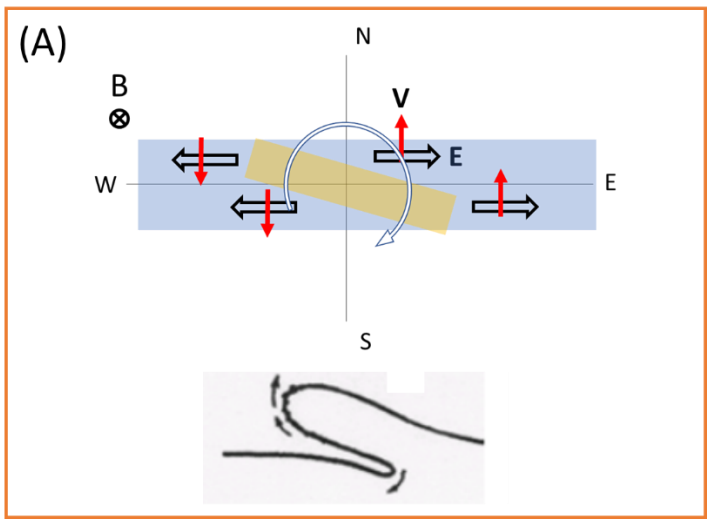
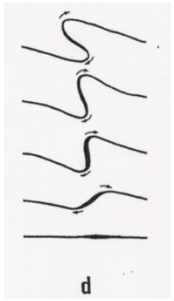



Figure D




Oguti, 1975

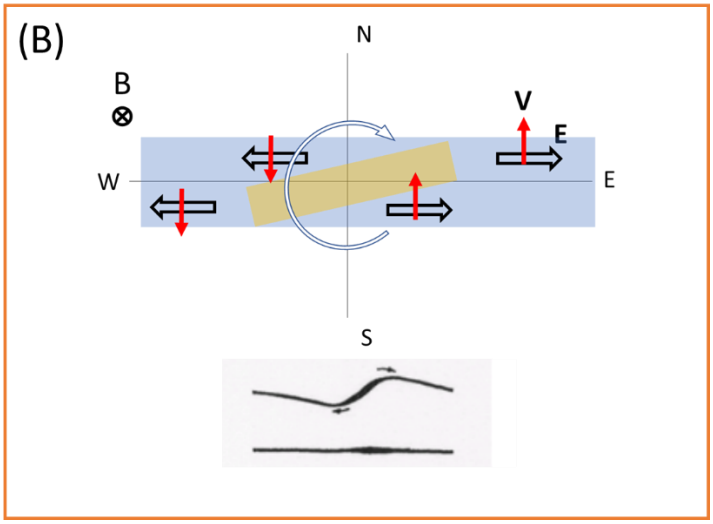



Figure E

The unfolding processes of auroral arc demonstrated above would be in accord with “the arc stays roughly E-W aligned, with the part of the arc at the centre of the spiral rotating as the spiral winds up” in the referee comments.

If examples of spiral auroras in Partamies et al., 2001, and Keiling et al., 2009 are an auroral type associated with unfolding processes, we can assume a single mechanism for producing spiral auroras from small to large scales.

If a single mechanism assumption is not unreasonable, we prefer to leave unchanged the title as “Are drivers of northern lights in the ionosphere?”.