The enigma of auroral spirals

G. Haerendel

Max Planck Institute for Extraterrestrial Physics, 85748 Garching, Germany

One of the most spectacular forms that the aurora borealis can assume is the large-scale spiral. Spirals are dominantly observed along the poleward boundary of the auroral oval during active periods. Two concepts have been pursued in explaining their origin and, in particular, the counterclockwise sense of rotation of the luminous structures when viewed along the magnetic field direction. An essentially magnetostatic theory, following Hallinan (1976), attributes the spiral pattern to the twisting of field-lines caused by a centrally located upward field-aligned current. According to Oguti (1981) and followers, a clockwise rotation of the plasma flow produces the anticlockwise structure. There are observations seemingly confirming or contradicting either theory. In this paper it is argued that both concepts are insufficient, in that only parts of the underlying physics are considered. Besides field-aligned currents and plasma flow, one has to take into at least two further aspects. The ionospheric conductivity, modified by particle precipitation, has an impact on the magnetospheric plasma dynamics. Furthermore, auroral arcs are not fixed entities, subject to distortions by plasma flows or twisted field-lines, but sites of transient releases of energy. We suggest that auroral spirals are ports of entry or exit of plasma into or out of the auroral oval. This way it can be understood why a clockwise plasma flow can create an anticlockwise luminous pattern.