

Earth's Magnetic Field and Lighting

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Lighting is a good illustration of how the weak Earth's magnetic field contributes into a shape of the heavy current atmospheric process.

A role of Earth's magnetic field usually is ignored in understanding of a lighting discharge. For a forked lighting, the discharge consists of a leader stroke, building steadily downward, and a return stroke, which runs from ground to clouds. The leader stroke progresses toward the ground by approximately 100m steps, lasting 2 μ s with 50 μ s pause. The discharge current can reach 20000 A.

We believe that division the lighting cord for the steps is caused by Earth's magnetic field.

The lighting is a powered conductor in Earth's magnetic field. The acting force F is a cross product which depends on mutual direction of the current I inside the conductor I in the external field B :

$$\vec{F} = I[\vec{l} \times \vec{B}]$$

Earth's magnetic field B varies from 25 to 65 μ T (microteslas) at the surface.

At 20000 A discharge and $B \sim 50 \mu$ T, each the meter of the lighting cord experiences action of 1N force, acting mostly on the ions. The average diameter of the lighting bolt is ~ 1 in=0.025 m. Mass of the air per 1m of that diameter is ~ 0.00077 kg. Therefore, the horizontal acceleration of the lighting bolt is as order of $\sim 1300m \cdot s^{-2}$. The normal-acting acceleration like that can shift the 0.025 m diameter lighting bolt for first 0.006 s, braking the channel. The circuit gets open. Then the discharge stops and electric field strength raises until a new breakdown and the following discharge. Then the process repeats consequently. A front of the stroke moves at 15000 m/s, thus the ions experience acceleration as much as $\sim 10^8 m \cdot s^{-2}$ between the collisions. The rate of this molecular acceleration also aids breaking the lighting bolt.

