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Mass-loading effect in the exterior cusp and plasma mantle

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We estimated the mass-loading effect of escaping ionospheric ions on the solar wind flow in the plasma mantle where ionospheric O^+ are found. The conservation of momentum requires substantial deceleration of the solar wind flow due to 16 times heavier mass of O^+ than H^+. For example, the mass-loading of 0.1 cm^{-3} O^+ to 10 cm^{-3} magnetosheath inflow into the exterior cusp results in about 14% ($= \frac{0.1*16}{10*1+0.1*16}$) loss of velocity if the tailward velocity of O^+ becomes the same as that of the solar wind in this region. With this final velocity, the total kinetic energy (H^+ and O^+) also decreases by 14% in the planetary frame. Since no heating effect is involved, this energy is converted to the charge separation, and hence the cusp current system. If the incoming flow velocity is 100 km/s, the electrostatic energy that is produced by such a dynamo mechanism will reach 3 W/km^2, which is comparable to the solar wind electromagnetic energy (that is used for the DP-2 system estimation), and is sufficient in powering the cusp current system although the access area is smaller than the magnetopause.

In solar wind rest frame, the magnetosheath inflow experiences information that "the field is connected to the ionosphere" twice: first by the loss of the charge that maintains the convection electric field to the ionosphere immediately after crossing the boundary, and then by meeting the ionospheric outflowing ions. In this sense the cusp magnetosphere is "double open".