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Plasma vortices, lateral forcing, and the superrotating Venus atmosphere

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New observations from Venus Express (VEX) show the existence of a large-scale vortex-like ion flow pattern in the Venus plasma tail. The flow pattern is characterized by besides a dominating antisunward flow, also a lateral flow component of solar wind (H+) and ionospheric (O+) ions. The lateral flow component is directed opposite to the Venus orbital motion. A test of the energy and momentum balance between solar wind H+ and ionospheric O+ indicates that the energy and momentum delivered to O+ is proportional to the loss of energy and momentum by solar wind H+. The combined antisunward and lateral H+ and O+ flow wraps over the planetary atmosphere, from the terminator into the nightside. The net lateral flow near Venus is in the direction of the Venus atmospheric superrotation. Further down in the Venus plasma tail the flow display a circular motion around the central tail axis. The general agreement in direction between the nightside ion flow over the Northern hemisphere, and the retrograde motion of the Venus atmosphere, implies a cause-effect relation between the ionospheric O+ flow and the atmospheric neutral flow. This underlying connection is further strengthened by the fact the the O+ flow velocity in the 200-300 km altitude range follows the same power law curve as that fitted to the atmospheric zonal wind velocity profile [1]. The combined ion + neutral wind profile therefore implies momentum balance between the ionospheric and atmospheric retrograde flow. The fact that the O+ flow is driven by solar wind forcing leaves us with the question: Is the superrotating upper atmosphere at Venus a consequence of solar wind forcing? Is the ion flow capable of accelerating, and maintaining, a superrotating upper atmosphere at Venus?
Combining ion data [2] with a fluid dynamic model of the energy and momentum transfer of ions to neutrals we find that this is certainly possible. The ionospheric O+ energy and momentum observed is sufficient to accelerate, and maintain superrotating velocites, after a few million years - minute compared to evolutionary time scales of a planet.

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