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Flux-rope Formation in the Ionosphere of Venus: Mechanisms and Observations

H. Y. Wei (1), **C. T. Russell** (1), T. L. Zhang (2), J. G. Luhmann (3), M. Delva (2)

(1) Institute of Geophysics and Planetary Physics, University of California, Los Angeles, CA 90095-1567, USA, (2) Space Research Institute, Austrian Academy of Sciences, OEAW, 8042 Graz, Austria, (3) Space Sciences Laboratory, University of California, Berkeley, CA 94720, USA. (email: hwei@igpp.ucla.edu; ph: 1-310-206-1208; fax: 310-206-8042)

Magnetic flux ropes have the structure of a twisted flux tube. They are created in the ionosphere of Venus by its interaction with the solar wind. They were first detected by Pioneer Venus Orbiter during solar maximum and also now by Venus Express during solar minimum. The formation of a flux rope is thought to occur as follows: a flux tube in the magnetic barrier at the ionopause first twists (possibly due to the shear-velocity gradient along the flux tube) and forms a helical structure near the boundary between the magnetic barrier and the ionosphere; later it sinks into the field-free ionosphere and becomes further twisted. Previous studies were more focused on the well-developed flux ropes below the ionopause. On Venus Express we also observe flux ropes during formation near the ionopause boundary. A flux rope during formation has its axial orientation nearly parallel to the averaged field direction of the magnetic barrier (the angle is usually less than 30 degrees). In contrast the axial orientation of a well-developed flux rope below the ionopause has a large angle to the field direction in the magnetic barrier. This paper discusses the study of these two types of flux ropes to understand their formation in the Venus ionosphere and their evolution. It may also improve our knowledge of flux-rope structures in other plasma environments like the ionospheres of Mars and Titan.