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The Strength of Venus Lightning

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Abstract

On Earth, lightning occurs about 100 times per second worldwide. The electromagnetic waves associated with the electrical discharge refract vertically when they reach the ionosphere and propagate nearly parallel to the almost vertical field lines at mid and high latitudes. In contrast to the Earth, the magnetic field lines at Venus are nearly horizontal over much of the planet, and the vertically propagating electromagnetic waves have difficulty entering the ionosphere except in places where the magnetic field is inclined at a significant angle to the horizontal. Nevertheless, significant amplitudes are seen and we can use these signals to test the lightning generation hypothesis. The waves we see with the fluxgate magnetometer on Venus Express are right-handed, and propagate along the direction of the magnetic field. These amplitudes are much greater than those in the Earth's ionosphere at the same frequencies. The fact that the waves are overwhelmingly right-handed indicates that the frequencies of the waves being detected are the frequencies being generated and are not aliased by the digital sampling of the detector, since only right-handed waves can travel in the plasma conditions of the Venus ionosphere. Thus, Venus lightning generates waves in the band from 40-60 Hz detected by Venus Express as well at 100 Hz as detected earlier with Pioneer Venus' narrow band detector.

The lightning-associated waves have much larger amplitudes than those in the terrestrial magnetosphere that have 10's of pT amplitudes. At Venus, amplitudes reach 1 nT peak to peak. However, the proper metric with which to compare the strength of the lightning-generated waves in the Poynting vector, is the electromagnetic energy flux. At Venus, the magnetic field strength in the ionosphere is 1000 times smaller than at Earth so the wave speed is less by a factor of about 1000 for the same ionospheric electric density. The smaller wave speed requires a larger wave amplitude (by a factor of about 30) to carry the same energy flux. Hence, the whistler-mode waves, and by inference the source lightning discharges, are as strong at Venus as they are at Earth.