This Week's Citation Classic

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Carpenter D L. Whistler studies of the plasmapause in the magnetosphere. 1. Temporal variations in the position of the knee and some evidence on plasma motions near the knee. *J. Geophys. Res.* **71**:693-709, 1966. [Radioscience Lab., Stanford Univ., Stanford, CA]

In the earth's space environment, at distances reaching 20,000 km in the equatorial plane, there is an abrupt geomagnetic-field-aligned density decrease called the 'plasmapause.' The dense enclosed 'plasmasphere' exhibits a diurnal asymmetry and varies in mean radius inversely with solarinduced disturbance activity. [The *SCI®* indicates that this paper has been cited over 295 times since 1966.]

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"During my early days as a graduate student in electrical engineering at Stanford, I obtained a part-time job under Professor R.A. Helliwell of the Radioscience Laboratory. The work involved analyzing data on 'whistlers,' naturally occurring signals in the several kilohertz range that originate in lightning flashes and propagate into space along the earth's curving, dipole-like magnetic field lines. Because of the highly dispersive properties of the magnetized plasma that whistlers encounter, those that arrive in the opposite hemisphere have an elegant spectral form. This form may be used to infer the electron density along the geomagnetic-field-line path as well as the maximum altitude of the path above the earth. Thus whistlers act as natural probes of conditions in space out to distances of ~30,000 km.

"In early studies in 1959-1960,[1] evidence was found of an unexpected electron density or 'knee' in space, at which the density drops suddenly by one or two orders of magnitude with increasing distance from the earth. There was some corroborating evidence from the USSR; data from two lunar probes showed unexpectedly low plasma densities in the outer portions of the earth's magnetic envelope or 'magnetosphere.'

"The results on the knee became part of my thesis work[2] and were published in 1963.[3] At that time, many newly discovered space phenomena were being reported. The knee effect attracted some attention, but there was a need for further documentation. This became possible after 1963, when the Division of Polar Programs of the National Science Foundation established a new observing station at Eights, Antarctica. A graduate student, Neil Brice, had flown to that region in 1962 and identified it as being exceptionally rich in whistler activity. Our Stanford field engineeer in 1963 at Eights, Michael Trimpi, had done an inspired job of collecting data. The magnetic tapes that he recorded showed the knee phenomenon in astonishing detail. Not only was it now possible to confirm the worldwide and permanent existence of the effect (which I now called the 'plasmapause'), but it was also found that its radial extent varied with local time, exhibiting a 'bulge' near dusk. Furthermore, the volume of the 'plasmasphere,' or region inside the plasmapause, was found to vary inversely with the level of solar induced disturbance activity in the magnetosphere.

"The most immediate reaction to my 1966 article summarizing these results came from theorists, who recognized the plasmapause or knee as evidence of a large scale plasma convection pattern established in the outer part of the magnetosphere by the impinging 'wind' of plasma from the sun. Other citations can be traced to the character of the work as an initial description of a large scale geophysical phenomenon which has important physical links to the particle radiation belts, to various types of wave propagation, and to the earth's regular ionosphere."

1. **Carpenter D L.** New experimental evidence of the effect of magnetic storms on the magnetosphere. *J. Geophys. Res* **67**:135-44. 1962.
2. *.The magnetosphere during magnetic storms; a Whistler analysis.* Stanford. CA: Stanford Electronic Labs.. Technical Report No. 12. June 1962. 72 p.
3. Whistler evidence of a 'knee' in the magnetosphenc ionization density profile. *J. Geophys. Res.* **68**:1675-82, 1963.