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Radio sounding of the solar corona with Mars Express, Venus Express and Rosetta from 2004 to 2011

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Abstract

The radio sounding technique is a powerful tool to investigate the large-scale structure of the solar corona when a radio transmitter is located near superior solar conjunction. Mars Express, in orbit about Mars, underwent solar conjunctions in August/September 2004, October/November 2006, December/January 2008/09 and December to March 2010/2011. Venus Express went through solar conjunction in 2006 and Rosetta in 2006 and 2010. Thus, the declining phase and the start of the new solar activity cycle could be covered.

As part of the Radio Science Experiments MaRS (Mars Express), Vera (Venus Express) and RSI (Rosetta), the solar corona was sounded using coherent dual-frequency downlinks of the three spacecraft during their respective solar conjunctions. The transmitted radio signals at X-band (8.4 GHz) and S-band (2.3 GHz) propagated through the dense plasma of the solar corona. Changes in carrier frequency and propagation delay reveal the large-scale coronal structure, the electron content and plasma turbulence as a function of distance from the Sun.

It could be observed that the level of frequency fluctuations follows the solar cycle in general. Extreme variations were observed when the signal path crossed large-scale structures like coronal mass ejections and streamers. Observed variations in electron content are correlated with SOHO/LASCO white light images. Complementary to coronagraph mapping, radio sounding provides a high temporal resolution. Thus, the fine-scale structures of a CME are identified in the data.

The observed total electron content as a function of distance follows the relation which was derived from the Ulysses solar conjunction in 1991 and which is obviously not changing over the solar cycles.