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Studying Venus' atmosphere and ionosphere with Planetary Radio Interferometry and Doppler Experiment (PRIDE)

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The Planetary Radio Interferometry and Doppler Experiment (PRIDE) is a technique that can provide a multi-disciplinary enhancement of the science return of planetary missions. By performing precise Doppler tracking of a spacecraft carrier radio signal, at Earth-based radio telescopes, and VLBI-style processing of these signals in phase-referencing mode, the technique allows the determination of the radial velocity and lateral coordinates of the spacecraft with very high accuracy[1].

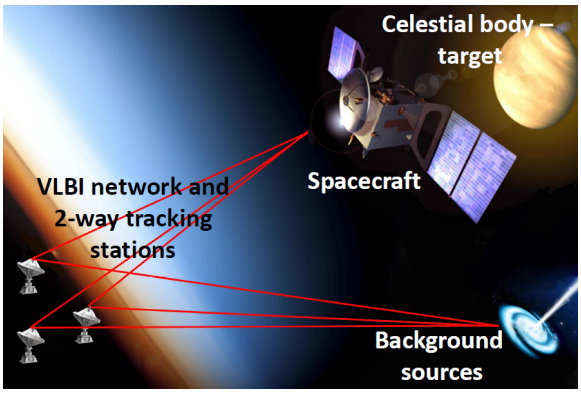

Figure 1: Generic PRIDE configuration.

Because of the accurate examination of the changes in phase and amplitude of the radio signal propagating from the spacecraft to the multiple stations on Earth, the PRIDE technique can be used for several fields of planetary research. The application of this technique for atmospheric studies has been assessed by observing ESA's Venus Express (VEX) during Venus occultation events in 2012 and 2014, and by participating in one of the Venus Express Atmospheric Drag Experiment (VExADE) campaigns in 2012. Both studies are contributing to the characterization efforts of the atmosphere and ionosphere of Venus.

During the Venus Express Atmospheric Drag Experiment (VExADE) campaigns VEX's orbit pericenter was lowered into an altitude range of approximately 165 to 175 km in order to probe Venus upper atmosphere above its north pole. The first VExADE campaigns were carried out between 2009-2010 using Doppler tracking data acquired by the VEX radio science experiment (VeRa), which provided the first in situ measurements of the density of Venus' polar thermosphere at solar minimum conditions [2]. In the December 2012 campaign the PRIDE-team participated by tracking VEX with several radio telescopes from the European VLBI Network (EVN) during pericenter passage. A Doppler frequency drop of $\sim$ 40 mHz was detected as VEX reached the lowest altitudes at around 170 km. The tracking data for each pericenter pass is fitted for precise orbit determination, from which drag acceleration estimates and the corresponding atmospheric mass density estimates are derived. Next to that, the PRIDE-team was involved in the tracking of VEX during ingress and egress occultation events. During two sessions of radio occultation experiments in April 2012 and March 2014, VEX was tracked with several telescopes from the European VLBI Network (EVN) at X-band. From these experiments, radio occultation profiles of neutral density and electron density of the dayside upper atmosphere and ionosphere of Venus were obtained from ingress and egress occultation tracking. These activities serve as demonstration of the applicability of the PRIDE technique for radio occultation studies, and provides a benchmark against the traditional Doppler tracking, for the same purposes.

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