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Near-field VLBI for Planetary Science

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Near-field VLBI is a radio astronomical technique that, when applied to observations of spacecraft, provides unique insights into those areas of a space mission's scientific programme requiring precise determination of the spacecraft's lateral position on the celestial sphere and its radial velocity. This technique was pioneered 30 years ago with the tracking of VEGA balloons to determine the wind field in the atmosphere of Venus.

The Planetary Radio Interferometry and Doppler Experiment (PRIDE) exploits near-field VLBI for accurate estimation of the state-vector of a spacecraft using arrays of Earth-based radio telescopes. PRIDE has proven to be very efficient in a number of recent VLBI experiments, starting with tracking the descent and landing of the Huygens Probe in the atmosphere of Saturn's moon Titan. PRIDE has conducted several observations of ESA's Venus Express mission for investigations ranging from its aero-braking maneuvers through the Venusian atmosphere to the scintillation structure in the interplanetary medium. On 28-29 December 2013, a global VLBI campaign including over 30 stations was conducted to observe Mars Express during its close fly-by of Phobos. PRIDE provided measurements of the spacecraft's differential lateral position relative to the ICRF background extragalactic radio sources with an accuracy of 100 to 10 mu;as (1sigma; RMS) over integration times from 60 to 1000 s.

With such accuracy, PRIDE can address scientific objectives spanning
the improvement of satellite ephemerides, ultra-precise celestial mechanics, the study of planetary atmospheres via occultations, and the characterization solar-wind and ionospheric effects on spacecraft transmissions. Improved satellite ephemerides would in turn allow a planetary system to be tied more firmly into the extragalactic reference frame, providing a major contribution to planetary geodesy and the definition of the Solar System reference system.

In collaboration with other on-board radio science experiments of a planetary mission, PRIDE enhances the overall mission's science return. We will review the technique of PRIDE and illustrate its capabilities in multi-disciplinary applications for planetary science missions.

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