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VLBI and Doppler tracking of spacecraft for planetary atmospheric studies

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The Planetary Radio Interferometry and Doppler Experiment (PRIDE) is a technique that can enhance the science return of planetary missions. By shadow tracking the spacecraft signal using radio telescopes from different VLBI networks around the world, the PRIDE technique provides precise open-loop Doppler and near-field VLBI observables (Duev et al. 2012, Bocanegra-Bahamon et al. 2018a) to find the radial velocity of the spacecraft and its position in the plane of the sky. This information is not only important for navigation, but it can also be used for many science applications. One such case is the study of planetary atmospheres by means of radio occultation experiments.

The application of PRIDE for atmospheric studies has been demonstrated by observing ESA's Venus Express (VEX) and Mars Express (MEX) during multiple Venus and Mars occultation events (Bocanegra-Bahamon et al. 2018b). From these observations density, temperature and pressure profiles of Venus and Mars were derived to characterize the planets' ionosphere and neutral atmosphere. The noise budget of the observations indicated that the quality of the detections are comparable to those obtained with NASA's and ESA's deep space networks (Bocanegra-Bahamon et al. 2018a). With PRIDE, making use of open-loop Doppler data, EVN stations were able to sound deeper layers of Venus' thick atmosphere when compared to closed-loop Doppler data provided by ESA's New Norcia. With the wideband spectral analysis of PRIDE, we showed that even with small antennas, such as the 12-m AuScope's Katherine, the spacecraft signal can be detected below Venus' cloud layer.

Radio occultation experiments with PRIDE can exploit the advantage of having access to large radio telescopes from different VLBI networks. Additionally, due to the wide coverage of the networks, the setup can be optimized to ensure high SNR signal detections. This offers a great opportunity when conducting radio occultation experiments with limited SNR of planets or moons with thick atmospheres. Such is the case of radio occultation experiments in the Jovian system, for which the PRIDE team is preparing as one of the experiments selected by ESA for the JUpiter ICy moons Explorer mission (JUICE) mission.