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Rheometry and numerical simulations of antennas onboard the Resonance spacecraft

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We report on the calibration effort for the monopole antennas onboard the Resonance spacecraft which will be launched in the middle of the next decade. The Resonance mission is dedicated to the study of the wave-particle interactions and plasma dynamics in the inner magnetosphere and the auroral region. It is intended to fly four spacecrafts on specific trajectories, so that on parts of the orbits the four spacecraft fly along the same field line (precisely speaking in the same flux tube) of the geomagnetic field. Time and space correlated measurements are planned which will reveal new insights into processes propagating along the field lines and phenomena which span large parts of the flux tubes.

The calibration is performed for four boom antennas and four cylindrical sensors at the boom tips. These antennas are devised for the measurement of electric fields and plasma parameters. We apply two methods for the antenna analysis: First, electrolytic tank measurements (rheometry), which is a method to determine the effective length vectors of electrically short antennas (in this context up to about 1MHz); second, numerical computer simulations which enable us to study also the transition to higher frequencies. The accuracy of the applied methods is about 1 degree for directions of effective axes and some percent for effective lengths and capacitances. With both methods we determined the following antenna parameters which are most relevant in the present context: The effective length vectors (comprising effective axes and effective lengths), and the antenna capacitance matrix. For that purpose the whole antenna-spacecraft system is treated as an 8-port antenna.

For the first time this kind of analysis is performed for a spaceborne antenna system consisting of boom monopoles and cylindrical tip antennas. The results show that the effective antenna lengths do not coincide with the physical ones but are tilted away from the solar panels by several degrees. The numerical computations based on ASAP and CONCEPT-II wire and patch models confirm very accurately the results obtained by rheometry. The knowledge of the acquired parameters is of great benefit to the Resonance mission. In particular, goniopolarimetry techniques like polarization analysis and direction finding depend crucially on the effective axes.