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Determining the effects of coating material on the Swarm satellites' Langmuir Probe plasma measurements

Candice Quinn

Email: cquinn@ucalgary.ca

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The European Space Agency's Swarm Satellite trio launched in 2013 to study the electromagnetic and plasma environment in Earth's upper atmosphere. Each satellite has two spherical Langmuir Probes (LP) that are identical except for the coatings. One is coated with titanium nitride (TiN) and the other is coated in gold (Au). Otherwise they are identical and operate independently. This research studies the effect of the coatings on plasma measurements. LPs measure electron current as a function of electrode voltage which is used to create current-voltage characteristics. Plasma properties such as electron density and temperature are then derived. To compare the probes measured current, each probe must be in the same operation mode. Swarm's LPs have two operation modes, Harmonic Mode (HM) and Sweep Mode (SM). HM is an innovation in LP measurement methods which provides a fast sampling rate and operates the majority of the time. SM is a conventional mode and operates for one second out of every 128 seconds.

Previous research has indicated that both TiN and Au coatings are susceptible to contamination. Contamination is a layer of neutral particles that are absorbed into the probe's surface during launch or in orbit. The particles modify the LP's capacitance and resistance, affecting the measured plasma current that introduce errors in the derived plasma parameters. To study any coating effects on Swarm's LPs, data is collected while a probe pair are in HM. The measurements are then compared to incoherent scatter radars measurements and to empirical models. SM data is analyzed individually to note behaviours such as hysteresis that can indicate contamination. Our findings indicate that the probes show differences in electron density and temperature measurements relative to each other with the greatest difference appearing near the poles.