5th International Conference on Tethers in Space

University of Michigan
May 24-26, 2016

Rethinking Use of the OML Model in Electric Sail Development

Nobie H. Stone[1]

Abstract

In 1924, Irvin Langmuir and H. M. Mott-Smith published a theoretical model for the complex plasma sheath phenomenon in which they identified some very special cases which greatly simplified the sheath and allowed a closed solution to the problem. The most widely used application is for an electrostatic, or "Langmuir," probe in laboratory plasma. Although the Langmuir probe is physically simple (a biased wire) the theory describing its functional behavior and its current-voltage characteristic is extremely complex and, accordingly, a number of assumptions and approximations are used in the LMS model. These simplifications, correspondingly, place limits on the model's range of application.

Adapting the LMS model to real-life conditions is the subject of numerous papers and dissertations. The Orbit-Motion Limited (OML) model that is widely used today is one of these adaptions that is a convenient means of calculating sheath effects. The OML equation for electron current collection by a positively biased body is simply:

$$I \cong A\, j_{eo} \frac{2}{\sqrt{\pi}} (\Phi)^{\frac{1}{2}}$$

where A is the area of the body and Φ is the electric potential on the body with respect to the plasma.

Since the Langmuir probe is a simple biased wire immersed in plasma, it is particularly tempting to use the OML equation in calculating the characteristics of the long, highly biased wires of an Electric Sail in the solar wind plasma. However, in order to arrive at the OML equation, a number of additional simplifying assumptions and approximations (beyond those made by Langmuir—Mott-Smith) are necessary. The OML equation is a good approximation when all conditions are met, but it would appear that the Electric Sail problem lies outside of the limits of applicability.

1 NeXolve Inc. Huntsville, AL (nobie.stone@wowway.com)