Swarm Probes Simulation Results

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Current predicted by OML for a spherical probe of radius a when $V < 0$

$$
\begin{aligned}
I_{net} &= \pi a^2 qn \left(\frac{2kT_i}{\pi m_i}\right)^{1/2} \left[e^{-x_{id}} + \left(1 + 2x_{id} - \frac{2qV}{kT_i}\right)\frac{\sqrt{\pi}}{2}\frac{\mathrm{erf}(x_{id})}{x_{id}}\right] \\
&- \pi a^2 qn \left(\frac{2kT_e}{\pi m_e}\right)^{1/2} \left\{\frac{x_{ed}+x_{em}}{2x_{ed}} e^{-(x_{ed}-x_{em})^2} + \frac{x_{ed}-x_{em}}{2x_{ed}} e^{-(x_{ed}+x_{em})^2}\right. \\
&+ \left.\left[\frac{1}{2} + x_{ed}^2 - \frac{qV}{kT_e}\right]\frac{\sqrt{\pi}}{2}\frac{\mathrm{erf}(x_{ed}-x_{em}) + \mathrm{erf}(x_{ed}+x_{em})}{x_{ed}}\right\}, \qquad (1)
\end{aligned}
$$

and for $V > 0$

$$
\begin{aligned}
I_{net} &= \pi a^2 qn \left(\frac{2kT_i}{\pi m_i}\right)^{1/2} \left\{\frac{x_{id}+x_{im}}{2x_{id}} e^{-(x_{id}-x_{im})^2} + \frac{x_{id}-x_{im}}{2x_{id}} e^{-(x_{id}+x_{im})^2}\right. \\
&+ \left.\left[\frac{1}{2} + x_{id}^2 - \frac{qV}{kT_i}\right]\frac{\sqrt{\pi}}{2}\frac{\mathrm{erf}(x_{id}-x_{im}) + \mathrm{erf}(x_{id}+x_{im})}{x_{id}}\right\} \\
&- \pi a^2 qn \left(\frac{2kT_e}{\pi m_e}\right)^{1/2} \left[e^{-x_{ed}} + \left(1 + 2x_{ed} - \frac{2qV}{kT_e}\right)\frac{\sqrt{\pi}}{2}\frac{\mathrm{erf}(x_{ed})}{x_{ed}}\right], \qquad (2)
\end{aligned}
$$

with

$$
x_d = \frac{v_d}{\sqrt{2kT/m}}, \qquad (3)
$$

$$
x_m = \sqrt{\frac{qV}{kT}}, \qquad (4)
$$

The density can be inferred from the admittance $\frac{dI_{ion}}{dV}$, using

$$
n = \frac{dI_{ion}}{dV}\left(\pi a^2 \frac{2q^2}{v_d}\sum_{j=1}^{N}\frac{n_j}{n_{tot}}\frac{1}{m_j}\mathrm{erf}\left(\frac{v_d}{\sqrt{2kT_i/m_j}}\right)\right)^{-1}, \qquad (5)
$$

If the ion effective mass is assumed to be $m_{eff} = 16$ amu, and the plasma flow be much larger than the ion thermal velocities, then the current is

$$
I_{ion} = \pi a^2 qnv_d\left(1 - \frac{2qV}{16m_p v_d^2}\right), \qquad (6)
$$

and the expression for the density is then,

$$n = \frac{dI_{ion}}{dV}\left(\pi a^2 \frac{2q^2}{16 m_p v_d}\right)^{-1}. \tag{7}$$

The analytic expression of the probe characteristic in the ion saturation and retardation region, can be combined to obtain an expression for the electron temperature (in eV)

$$T_e = \frac{I_{ret} - I_{ion} - d_{ion}(V_{ret} - V_{ion})}{d_{ret} - d_{ion}}, \tag{8}$$

Tables Description

In the tables, I_{sim} is the current from kinetic simulations, while, $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML_{16}}}$ are the relative differences between I_{sim} and the currents predicted with Eqs. 1 (I_{OML}) and 6 ($I_{OML_{16}}$) respectively. ϵ_{OML} and $\epsilon_{OML_{16}}$ are defined as follow

$$\epsilon_{I_{OML}} = \frac{I_{sim} - I_{OML}}{I_{sim}} \tag{9}$$

$$\epsilon_{I_{OML_{16}}} = \frac{I_{sim} - I_{OML_{16}}}{I_{sim}}. \tag{10}$$

$\delta_{I_{sim}}$ in tables are the relative uncertainties on the currents obtained from simulations.

$$\delta_{I_{sim}} = \frac{\Delta I_{sim}}{I_{sim}} \tag{11}$$

The uncertainties in the simulated collected currents are calculated from

$$\Delta I_{sim} = \frac{\sigma}{\sqrt{\mathcal{N}}}, \tag{12}$$

where σ is the standard deviation in the calculated current and $\mathcal{N} = t_{tot}/\tau$, where t_{tot} is the total simulation time at steady state, and τ is the decorrelation time which in this case, is taken to be ten time steps, $\tau = 10\ dt$.

In the tables, ϵ_{n_I}, ϵ_n, and $\epsilon_{n_{16}}$ are the relative errors in the densities inferred from 1 (solved for n), 5, and 7, respectively. Relative uncertainties in the inferred densities are label under δ_{n_I} and δ_n.

$$\epsilon_{n_x} = \frac{n_{inferred} - n_{input}}{n_{inferred}} \tag{13}$$

$$\delta n_x = \frac{\Delta n_{inferred}}{n_{inferred}} \tag{14}$$

The uncertainties in the inferred densities, $\Delta n_{inferred}$, are calculated using partial derivatives in Eq. 1 (solved for n), 5, and 7. When the satellite is included in the simulation, two independent probe measurements are obtained, labeled as $LP1$ and $LP2$ in the Tables, where LPA refers to the average of the two probes.

Note that in the tables, in some cases where the density is calculated from computed admittance, the magnitude of the calculated uncertainty in the inferred density is larger than the calculated relative error. Results obtained in such cases are therefore inconclusive.

In Table 25, column labeled $Swarm(Yes/No)$ refers to the presence or absence of the satellite in the simulation domain. The $\pm$ sign in $|\vec{B}|$ column refers to the sign of B_z. In table 25, ϵ_{T_e} is the relative error between the inferred temperature and the one used as input in the simulations,

$$\epsilon_{T_e} = \frac{T_{e_{inferred}} - T_{e_{input}}}{T_{e_{inferred}}}, \tag{15}$$

and as for δn_x, δ_{T_e} is the relative uncertainty in the inferred electron temperature resulting from uncertainties in the calculated currents (see Eq. 12).

$$\delta T_e = \frac{\Delta T_{e_{inferred}}}{T_{e_{inferred}}} \tag{16}$$

$\Delta T_{e_{sim}}$ values are calculated using partial derivatives in Eq. 8. The $-$ and $+$ signs in the tables indicate that the inferred parameters are underestimated and overestimated, respectively, compared to the inputs in simulations.

n $10^{10}m^{-3}$	T_e eV	T_i eV	m_{eff} amu	λ_D mm	V_p V	I_{sim} nA	δI_{sim} %	$\epsilon_{I_{OML}}$ %	$\epsilon_{I_{OML16}}$ %
3.16	0.070	0.070	7.4	11.1	-3.5	5.103	0.3	2.2	34.8
3.16	0.070	0.070	7.4	11.1	-4.5	5.988	0.4	2.2	37.8
3.16	0.070	0.070	7.4	11.1	-5.5	6.886	0.3	2.4	40.1
10.00	0.070	0.068	5.9	6.2	-3.5	18.608	0.3	1.9	43.4
10.00	0.070	0.068	5.9	6.2	-4.5	22.232	0.5	2.5	47.0
10.00	0.070	0.068	5.9	6.2	-5.5	25.703	0.3	2.3	49.2
31.6	0.070	0.070	4.1	3.5	-3.5	74.462	0.4	1.4	55.2
31.6	0.070	0.070	4.1	3.5	-4.5	90.428	0.6	1.8	58.8
31.6	0.070	0.070	4.1	3.5	-5.5	106.059	0.4	1.8	**61.1**
63.2	0.082	0.079	13.7	2.7	-3.5	73.020	0.7	2.0	8.8
63.2	0.082	0.079	13.7	2.7	-4.5	83.467	**1.1**	3.2	10.7
63.2	0.082	0.079	13.7	2.7	-5.5	92.387	0.7	2.5	10.7
1.00	0.156	0.116	8.3	29.4	-3.5	1.515	0.4	3.1	30.5
1.00	0.156	0.116	8.3	29.4	-4.5	1.770	0.4	3.5	33.4
1.00	0.156	0.116	8.3	29.4	-5.5	2.032	0.2	**4.2**	35.8
3.16	0.140	0.113	11.4	15.7	-3.5	3.999	0.3	2.3	16.8
3.16	0.140	0.113	11.4	15.7	-4.5	4.588	0.4	2.7	18.8
3.16	0.140	0.113	11.4	15.7	-5.5	5.175	0.3	3.1	20.3
10.0	0.140	0.112	13.0	8.8	-3.5	11.902	0.4	2.4	11.5
10.0	0.140	0.112	13.0	8.8	-4.5	13.520	0.5	2.6	12.8
10.0	0.140	0.112	13.0	8.8	-5.5	15.176	0.4	3.1	14.0
31.6	0.140	0.089	15.9	5.0	-3.5	34.381	0.5	2.3	3.2
31.6	0.140	0.089	15.9	5.0	-4.5	38.595	0.7	2.6	3.4
31.6	0.140	0.089	15.9	5.0	-5.5	42.745	0.5	2.7	3.5
3.16	0.210	0.120	12.6	19.2	-3.5	3.816	0.3	2.8	12.8
3.16	0.210	0.120	12.6	19.2	-4.5	4.356	0.5	3.4	14.5
3.16	0.210	0.120	12.6	19.2	-5.5	4.883	0.3	3.6	15.6
10.0	0.220	0.107	11.3	11.0	-3.5	12.761	0.3	2.5	17.4
10.0	0.220	0.107	11.3	11.0	-4.5	14.636	0.5	2.9	19.4
10.0	0.220	0.107	11.3	11.0	-5.5	16.521	0.3	3.3	21.0
10.0	0.280	0.121	16.0	12.4	-3.5	10.727	**1.1**	1.1	1.9
10.0	0.280	0.121	16.0	12.4	-4.5	12.093	1.0	1.7	2.5
10.0	0.280	0.121	16.0	12.4	-5.5	13.553	0.3	3.0	3.7

Table 1: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate an overestimation while negative signs an underestimation.

n $10^{10}m^{-3}$	T_e eV	T_i eV	m_{eff} amu	λ_D mm	ϵ_{n_I} %	δn_I %	ϵ_n %	$\epsilon_{n_{16}}$ %	$\delta_{n-n_{16}}$ %
3.16	0.070	0.070	7.4	11.1	2.2	0.4	3.1	55.4	1.4
10.00	0.070	0.068	5.9	6.2	2.5	0.5	3.3	64.6	1.5
31.6	0.070	0.070	4.1	3.5	1.8	0.6	2.6	**74.9**	1.7
63.2	0.082	0.079	13.7	2.7	3.2	**1.1**	4.3	18.0	4.3
1.00	0.156	0.116	8.3	29.4	3.5	0.4	7.2	51.4	1.5
3.16	0.140	0.113	11.4	15.7	2.7	0.5	5.8	32.4	1.6
10.0	0.140	0.112	13.0	8.8	2.6	0.7	5.8	23.2	2.2
31.6	0.140	0.089	15.9	5.0	2.6	0.5	4.3	5.0	3.2
3.16	0.210	0.120	12.6	19.0	**3.4**	0.5	6.6	25.6	1.8
10.0	0.220	0.107	11.3	11.0	2.9	0.5	5.7	33.1	1.8
10.0	0.280	0.121	16.0	12.4	1.7	1.0	**10.3**	10.6	**4.4**

Table 2: Relative errors in the inferred density calculated from probe simulations results. $\epsilon_{I_{pic}}$ are the relative errors when Eq. 1 is used to infer density. ϵ_n and ϵ_n, correspond to relative errors in inferred density when Eq. 5 and 7 are used respectively. δ_{n_I} and δ_n represent the relative uncertainties in their respective inferred densities. Positive errors indicate that the calculated density is overestimated while negative signs refer to an underestimation. In all cases, the ram velocity is 7673 m/s.

n	Te	Ti	m_{eff}	λ_D	v_d	
$3.16 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.070\ eV$	$7.7\ amu$	$11.1\ mm$	$7673\ m/s$	
V_f V	V_p V	LP_x	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\epsilon_{I_{OML16}}$ %	δI_{sim} %
-0.201	-2.701	LP_1	4.311	3.1	32.1	1.3
-0.201	-2.701	LP_2	4.375	4.5	33.1	1.2
-0.201	-2.701	LP_A	4.343	3.8	32.6	0.9
-0.201	-3.701	LP_1	5.229	4.1	36.7	1.0
-0.201	-3.701	LP_2	5.333	5.9	37.9	1.0
-0.201	-3.701	LP_A	5.282	5.0	37.3	0.7
-1.0	-3.5	LP_1	4.468	-8.5	27.6	1.6
-1.0	-3.5	LP_2	4.589	-5.6	29.5	1.6
-1.0	-3.5	LP_A	4.529	-7.0	28.6	1.1
-1.0	-4.5	LP_1	5.324	-6.8	32.0	1.2
-1.0	-4.5	LP_2	5.412	-5.1	32.1	1.2
-1.0	-4.5	LP_A	5.368	-5.9	32.6	0.9
-2.0	-4.5	LP_1	4.453	-27.7	18.7	1.2
-2.0	-4.5	LP_2	4.507	-26.2	19.7	1.2
-2.0	-4.5	LP_A	4.480	-26.9	19.2	0.9
-2.0	-5.5	LP_1	5.134	-27.1	22.0	1.0
-2.0	-5.5	LP_2	5.230	-24.8	23.4	1.0
-2.0	-5.5	LP_A	5.182	-25.9	22.7	0.7

Table 3: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.6\%$

SWARM LP ION SATURATION CURRENT C02

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.068\ eV$	$5.9\ amu$	$6.2\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	δI_{sim}
V	V		nA	%	%	%
-0.195	-2.695	LP_1	15.658	3.9	40.9	1.6
-0.195	-2.695	LP_2	15.770	4.6	41.4	1.6
-0.195	-2.695	LP_A	15.714	4.3	41.1	1.1
-0.195	-3.695	LP_1	19.038	3.5	45.0	1.3
-0.195	-3.695	LP_2	19.439	5.5	46.1	1.3
-0.195	-3.695	LP_A	19.238	4.5	45.6	0.9
-1.0	-3.5	LP_1	17.217	-3.0	40.6	1.9
-1.0	-3.5	LP_2	17.218	-3.0	40.6	2.0
-1.0	-3.5	LP_A	17.218	-3.0	40.6	1.4
-1.0	-4.5	LP_1	20.458	-2.9	44.0	1.5
-1.0	-4.5	LP_2	20.806	-1.2	45.0	1.5
-1.0	-4.5	LP_A	20.632	-2.1	44.5	1.1
-2.0	-4.5	LP_1	18.648	-12.9	38.6	2.5
-2.0	-4.5	LP_2	18.676	-12.9	38.7	2.6
-2.0	-4.5	LP_A	18.665	-12.8	38.6	1.1
-2.0	-5.5	LP_1	21.981	-11.0	42.3	1.6
-2.0	-5.5	LP_2	22.173	-10.0	42.8	1.5
-2.0	-5.5	LP_A	22.077	-10.5	42.6	1.1

Table 4: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.5\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$31.6 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.070\ eV$	$4.1\ amu$	$3.5\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.195	-2.695	LP_1	60.311	1.0	51.2	1.4
-0.195	-2.695	LP_2	60.605	1.4	51.4	1.3
-0.195	-2.695	LP_A	60.458	1.2	51.3	1.0
-1.0	-3.5	LP_1	69.054	-4.1	52.8	2.0
-1.0	-3.5	LP_2	67.559	-6.4	51.8	2.0
-1.0	-3.5	LP_A	68.306	-5.2	52.3	1.4
-1.0	-4.5	LP_1	82.966	-4.8	56.0	1.1
-1.0	-4.5	LP_2	83.901	-3.6	56.5	1.0
-1.0	-4.5	LP_A	83.434	-4.2	56.3	0.7
-2.0	-4.5	LP_1	76.356	-13.9	52.2	1.4
-2.0	-4.5	LP_2	77.879	-11.6	53.2	1.4
-2.0	-4.5	LP_A	77.118	-12.7	52.7	1.0
-2.0	-5.5	LP_1	90.890	-12.2	55.6	1.1
-2.0	-5.5	LP_2	92.448	-10.3	56.3	1.1
-2.0	-5.5	LP_A	91.669	-11.3	56.0	0.8

Table 5: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.1\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$63.2 \times 10^{10} m^{-3}$	$0.082\ eV$	$0.079\ eV$	$13.7\ amu$	$2.7\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.223	-2.723	LP_1	64.079	1.6	7.7	1.9
-0.223	-2.723	LP_2	66.806	5.7	11.5	1.9
-0.223	-2.723	LP_A	65.443	3.7	9.6	1.3
-1.0	-3.5	LP_1	69.716	-0.5	6.5	2.1
-1.0	-3.5	LP_2	71.276	1.7	8.5	2.1
-1.0	-3.5	LP_A	70.496	0.6	7.5	1.5
-1.0	-4.5	LP_1	82.321	3.9	11.4	1.8
-1.0	-4.5	LP_2	80.172	1.3	9.0	1.8
-1.0	-4.5	LP_A	81.246	2.6	10.2	1.3
-2.0	-4.5	LP_1	76.197	-3.9	4.2	2.3
-2.0	-4.5	LP_2	79.652	0.6	8.4	2.2
-2.0	-4.5	LP_A	77.925	-1.6	6.4	1.6
-2.0	-5.5	LP_1	88.760	0.6	9.0	1.9
-2.0	-5.5	LP_2	87.962	-1.4	7.1	1.9
-2.0	-5.5	LP_A	87.861	-0.4	8.1	1.3

Table 6: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 3.0\%$

SWARM LP ION SATURATION CURRENT C05

n	Te	Ti	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3 amu	29.4 mm	7673 m/s	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.513	-3.013	LP_1	1.217	-7.8	20.8	1.3
-0.513	-3.013	LP_2	1.222	-7.4	21.1	1.3
-0.513	-3.013	LP_A	1.220	-7.6	21.0	0.9
-0.513	-4.013	LP_1	1.448	-6.7	25.0	1.1
-0.513	-4.013	LP_2	1.443	-7.1	24.8	1.1
-0.513	-4.013	LP_A	1.446	-6.9	24.9	0.7
-1.0	-3.5	LP_1	1.191	-19.6	14.1	1.4
-1.0	-3.5	LP_2	1.211	-17.7	15.5	1.4
-1.0	-3.5	LP_A	1.201	-18.7	14.8	1.0
-1.0	-4.5	LP_1	1.392	-19.2	17.7	1.1
-1.0	-4.5	LP_2	1.399	-18.5	18.2	1.0
-1.0	-4.5	LP_A	1.396	-18.8	17.9	0.7
-2.0	-4.5	LP_1	1.136	-46.0	-0.8	1.7
-2.0	-4.5	LP_2	1.153	-43.9	0.6	1.7
-2.0	-4.5	LP_A	1.145	-44.9	0.0	1.2
-2.0	-5.5	LP_1	1.300	-45.5	2.5	1.1
-2.0	-5.5	LP_2	1.328	-42.4	4.6	1.1
-2.0	-5.5	LP_A	1.314	-44.0	3.6	0.8

Table 7: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 0.7\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$3.16 \times 10^{10} m^{-3}$	$0.140\ eV$	$0.113\ eV$	$11.4\ amu$	$15.7\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.454	-2.954	LP_1	3.497	-0.2	13.6	1.5
-0.454	-2.954	LP_2	3.545	1.2	14.7	1.5
-0.454	-2.954	LP_A	3.521	0.5	14.2	1.1
-1.0	-3.5	LP_1	3.647	-4.1	11.3	1.5
-1.0	-3.5	LP_2	3.680	-3.2	12.1	1.5
-1.0	-3.5	LP_A	3.663	-3.6	11.7	1.1
-1.0	-4.5	LP_1	4.187	-3.5	13.6	1.2
-1.0	-4.5	LP_2	4.256	-1.8	15.0	1.1
-1.0	-4.5	LP_A	4.222	-2.7	14.3	0.8
-2.0	-4.5	LP_1	3.771	-15.0	4.0	1.9
-2.0	-4.5	LP_2	3.809	-13.8	5.0	1.9
-2.0	-4.5	LP_A	3.790	-14.4	4.5	1.36
-2.0	-5.5	LP_1	4.245	-14.8	5.6	1.2
-2.0	-5.5	LP_2	4.304	-13.2	7.0	1.2
-2.0	-5.5	LP_A	4.275	-14.0	6.3	0.8

Table 8: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.3\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.140\ eV$	$0.112\ eV$	$13.0\ amu$	$8.8\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.443	-2.943	LP_1	10.730	2.6	11.0	1.3
-0.443	-2.943	LP_2	10.902	4.2	12.4	1.3
-0.443	-2.943	LP_A	10.816	3.4	11.7	0.9
-1.0	-3.5	LP_1	11.106	-1.6	7.9	2.0
-1.0	-3.5	LP_2	11.518	2.0	11.2	2.0
-1.0	-3.5	LP_A	11.312	0.2	9.5	1.4
-1.0	-4.5	LP_1	12.949	1.3	11.6	1.5
-1.0	-4.5	LP_2	13.3	3.8	13.8	1.4
-1.0	-4.5	LP_A	13.116	2.5	12.7	1.0
-2.0	-4.5	LP_1	12.383	-3.2	7.5	2.2
-2.0	-4.5	LP_2	12.365	-3.4	7.4	2.2
-2.0	-4.5	LP_A	12.374	-3.3	7.4	1.5
-2.0	-5.5	LP_1	13.972	-2.2	9.3	1.4
-2.0	-5.5	LP_2	14.120	-1.1	10.2	1.3
-2.0	-5.5	LP_A	14.046	-1.7	9.8	1.0

Table 9: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 2.2\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$31.6 \times 10^{10} m^{-3}$	$0.140\ eV$	$0.089\ eV$	$15.9\ amu$	$5.0\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.437	-2.937	LP_1	31.629	3.0	3.9	1.5
-0.437	-2.937	LP_2	31.534	2.7	3.6	1.6
-0.437	-2.937	LP_A	31.581	2.9	3.7	1.1
-1.0	-3.5	LP_1	33.473	1.8	2.6	1.7
-1.0	-3.5	LP_2	33.097	0.7	1.5	1.6
-1.0	-3.5	LP_A	33.285	1.2	2.1	1.2
-1.0	-4.5	LP_1	37.917	3.0	3.8	1.7
-1.0	-4.5	LP_2	37.744	2.5	3.3	1.7
-1.0	-4.5	LP_A	37.830	2.7	3.5	1.2
-2.0	-4.5	LP_1	36.316	-1.3	-0.5	1.8
-2.0	-4.5	LP_2	36.057	-2.0	-1.2	1.8
-2.0	-4.5	LP_A	36.187	-1.7	-0.8	1.3
-2.0	-5.5	LP_1	41.0442	0.8	1.6	1.4
-2.0	-5.5	LP_2	40.900	0.5	1.3	1.4
-2.0	-5.5	LP_A	40.972	0.6	1.5	1.0

Table 10: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.1\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$3.16 \times 10^{10} m^{-3}$	$0.210\ eV$	$0.120\ eV$	$12.6\ amu$	$19.2\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.719	-3.219	LP_1	3.481	0.4	10.2	1.5
-0.719	-3.219	LP_2	3.466	0.0	9.8	1.5
-0.719	-3.219	LP_A	3.474	0.2	10.0	1.0
-1.0	-3.5	LP_1	3.514	-2.5	8.0	1.5
-1.0	-3.5	LP_2	3.522	-2.3	8.2	1.5
-1.0	-3.5	LP_A	3.518	-2.4	8.1	1.0
-1.0	-4.5	LP_1	4.059	-0.7	10.8	1.1
-1.0	-4.5	LP_2	4.002	-2.2	9.6	1.2
-1.0	-4.5	LP_A	4.031	-1.4	10.2	0.8
-2.0	-4.5	LP_1	3.621	-12.8	0.1	1.8
-2.0	-4.5	LP_2	3.624	-12.8	0.1	1.8
-2.0	-4.5	LP_A	3.623	-12.8	0.1	1.2
-2.0	-5.5	LP_1	4.067	-12.4	1.5	1.2
-2.0	-5.5	LP_2	4.100	-11.5	2.3	1.2
-2.0	-5.5	LP_A	4.084	-11.9	1.9	0.9

Table 11: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.2\%$

SWARM LP ION SATURATION CURRENT C10

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.220\ eV$	$0.107\ eV$	$11.3\ amu$	$11.0\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.752	-3.252	LP_1	11.689	0.3	15.1	1.1
-0.752	-3.252	LP_2	11.884	2.0	16.5	1.1
-0.752	-3.252	LP_A	11.787	1.1	15.8	0.8
-1.0	-3.5	LP_1	12.012	-0.6	14.8	1.7
-1.0	-3.5	LP_2	11.977	-0.8	14.6	1.7
-1.0	-3.5	LP_A	11.995	-0.7	14.7	1.2
-1.0	-4.5	LP_1	13.768	-0.2	16.8	1.2
-1.0	-4.5	LP_2	13.754	-0.3	16.7	1.2
-1.0	-4.5	LP_A	13.761	-0.3	16.8	0.8
-2.0	-4.5	LP_1	13.043	-5.8	12.2	2.1
-2.0	-4.5	LP_2	13.125	-5.2	12.7	2.1
-2.0	-4.5	LP_A	13.084	-5.5	12.5	1.5
-2.0	-5.5	LP_1	14.753	-5.2	14.1	1.4
-2.0	-5.5	LP_2	14.761	-5.2	14.1	1.4
-2.0	-5.5	LP_A	14.757	-5.2	14.1	1.0

Table 12: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.0\%$

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.280\ eV$	$0.121\ eV$	$16.0\ amu$	$12.4\ mm$	$7673\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-0.990	-3.490	LP_1	10.583	2.5	3.4	1.3
-0.990	-3.490	LP_2	10.607	2.7	3.7	1.3
-0.990	-3.490	LP_A	10.595	2.6	3.5	0.9
-1.0	-3.5	LP_1	10.616	2.7	3.6	1.8
-1.0	-3.5	LP_2	10.402	0.7	1.6	1.8
-1.0	-3.5	LP_A	10.509	1.7	2.6	1.3
-1.0	-4.5	LP_1	11.948	3.2	4.1	1.3
-1.0	-4.5	LP_2	12.001	3.7	4.6	1.3
-1.0	-4.5	LP_A	11.974	3.4	4.4	0.9
-2.0	-4.5	LP_1	11.482	-0.7	0.3	2.2
-2.0	-4.5	LP_2	11.723	1.4	2.3	2.2
-2.0	-4.5	LP_A	11.603	0.4	1.3	1.6
-2.0	-5.5	LP_1	12.723	-0.5	0.4	1.6
-2.0	-5.5	LP_2	12.787	0.0	0.9	1.6
-2.0	-5.5	LP_A	12.755	-0.3	0.6	1.1

Table 13: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 2.0\%$

SWARM LP ION SATURATION CURRENT C12

n	Te	Ti	m_{eff}	λ_D	v_d	
$3.16 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.070\ eV$	$7.4.0\ amu$	$11.1\ mm$	$8173\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	5.182	-7.7	29.8	2.2
-1.0	-4.5	LP_2	5.424	-2.9	33.0	2.1
-1.0	-4.5	LP_A	5.303	-5.2	31.4	1.5
-2.0	-5.5	LP_1	5.105	-24.7	21.7	2.1
-2.0	-5.5	LP_2	5.278	-20.6	24.3	2.2
-2.0	-5.5	LP_A	5.192	-22.7	23.0	1.5

Table 14: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 3.9\%$

SWARM LP ION SATURATION CURRENT C13

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.068\ eV$	$5.9\ amu$	$6.2\ mm$	$8173\ m/s$	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML_{16}}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	20.403	-0.7	43.6	2.6
-1.0	-4.5	LP_2	20.457	-0.4	43.8	2.6
-1.0	-4.5	LP_A	20.430	-0.5	43.7	1.9
-1.0	-5.5	LP_1	21.680	-9.2	41.6	2.6
-1.0	-5.5	LP_2	21.985	-7.6	42.5	2.6
-1.0	-5.5	LP_A	21.832	-8.4	42.1	1.8

Table 15: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 0.8\%$

SWARM LP ION SATURATION CURRENT C14

n	Te	Ti	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3 amu	29.4 mm	8173 m/s	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	1.389	-17.8	17.2	1.7
-1.0	-4.5	LP_2	1.399	-18.0	17.8	1.8
-1.0	-4.5	LP_A	1.394	-17.4	17.5	1.2
-2.0	-5.5	LP_1	1.318	-40.8	4.0	2.9
-2.0	-5.5	LP_2	1.309	-41.7	3.4	3.0
-2.0	-5.5	LP_A	1.314	-41.3	3.7	2.1

Table 16: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.0\%$

SWARM LP ION SATURATION CURRENT C15

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	0.280 eV	0.121 eV	16.0 amu	12.4 mm	8173 m/s	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	12.167	4.8	5.4	3.2
-1.0	-4.5	LP_2	11.810	1.9	2.6	3.2
-1.0	-4.5	LP_A	11.989	3.3	4.0	2.3
-2.0	-5.5	LP_1	12.725	-0.1	0.6	2.1
-2.0	-5.5	LP_2	12.794	0.4	1.1	2.1
-2.0	-5.5	LP_A	12.759	0.2	0.8	1.5

Table 17: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.3\%$

SWARM LP ION SATURATION CURRENT C16

n	Te	Ti	m_{eff}	λ_D	v_d	
$3.16 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.070\ eV$	$7.4\ amu$	$11.1\ mm$	$7173\ m/s$	
V_f V	V_p V	LP_x	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\epsilon_{I_{OML_{16}}}$ %	δI_{sim} %
-1.0	-4.5	LP_1	5.366	-8.5	32.6	1.8
-1.0	-4.5	LP_2	5.360	-8.6	32.5	1.8
-1.0	-4.5	LP_A	5.363	-8.6	32.5	1.3
-2.0	-5.5	LP_1	5.193	-29.4	22.4	2.2
-2.0	-5.5	LP_2	5.167	-30.8	22.0	2.2
-2.0	-5.5	LP_A	5.180	-29.7	22.2	1.6

Table 18: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 0.3\%$

SWARM LP ION SATURATION CURRENT C17

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	$0.070\ eV$	$0.068\ eV$	$5.9\ amu$	$6.2\ mm$	$7173\ m/s$	
V_f V	V_p V	LP_x	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\epsilon_{I_{OML_{16}}}$ %	δI_{sim} %
-1.0	-4.5	LP_1	21.069	-3.0	45.7	2.6
-1.0	-4.5	LP_2	21.591	-0.5	47.0	2.6
-1.0	-4.5	LP_A	21.330	-1.7	46.3	1.8
-2.0	-5.5	LP_1	22.216	-13.7	42.6	2.4
-2.0	-5.5	LP_2	22.428	-12.6	43.1	2.4
-2.0	-5.5	LP_A	22.322	-13.1	42.9	1.7

Table 19: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.7\%$

SWARM LP ION SATURATION CURRENT C18

n	Te	Ti	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3 amu	29.4 mm	7173 m/s	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	1.401	-20.5	18.3	1.6
-1.0	-4.5	LP_2	1.410	-19.7	18.8	1.6
-1.0	-4.5	LP_A	1.405	-20.1	18.5	1.1
-2.0	-5.5	LP_1	1.303	-48.6	2.1	2.0
-2.0	-5.5	LP_2	1.322	-46.4	3.5	2.0
-2.0	-5.5	LP_A	1.313	-48.5	2.9	1.4

Table 20: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 1.1\%$

SWARM LP ION SATURATION CURRENT C19

n	Te	Ti	m_{eff}	λ_D	v_d	
$10.0 \times 10^{10} m^{-3}$	0.280 eV	0.121 eV	16.0 amu	12.4 mm	7173 m/s	
V_f	V_p	LP_x	I_{sim}	$\epsilon_{I_{OML}}$	$\epsilon_{I_{OML16}}$	δI_{sim}
V	V		nA	%	%	%
-1.0	-4.5	LP_1	11.850	2.6	3.4	2.4
-1.0	-4.5	LP_2	12.114	4.7	5.5	2.5
-1.0	-4.5	LP_A	11.982	3.7	4.5	1.7
-2.0	-5.5	LP_1	12.573	-2.2	-1.4	2.5
-2.0	-5.5	LP_1	12.907	0.4	1.2	2.5
-2.0	-5.5	LP_1	12.740	-0.9	-0.1	1.7

Table 21: I_{sim} are the ion currents calculated from simulations. $\epsilon_{I_{OML}}$ and $\epsilon_{I_{OML16}}$ are the relative errors in currents from simulations with respect to those predicted with OML theory, Eq. 1 and 6, respectively. $\delta_{I_{sim}}$ is the relative uncertainty in the currents from simulations. Positive errors indicate overestimation while negative signs refer to an underestimation. $\delta_{mesh} = 2.4\%$

n	Te	Ti	m_{eff}	λ_D	V_f	LP_x	ϵ_{n_I}	δ_{n_I}	ϵ_n	$\epsilon_{n_{16}}$	δ_n
$10^{10}m^{-3}$	eV	eV	amu	mm	V		%	%	%	%	%
3.16	0.070	0.070	7.4	11.1	-0.201	LP_1	3.1	1.8	8.7	58.0	8.3
					-0.201	LP_2	4.5	1.8	12.5	59.7	8.0
					-0.201	LP_A	3.8	1.2	10.6	58.9	5.7
					-1.0	LP_1	-8.5	2.2	2.0	54.9	11.4
					-1.0	LP_2	-5.6	2.1	-2.0	53.1	12.0
					-1.0	LP_A	-7.0	1.5	0.0	54.0	8.3
					-2.0	LP_1	-27.7	1.6	-23.0	43.4	10.7
					-2.0	LP_2	-26.2	1.6	-16.0	46.6	10.2
					-2.0	LP_A	-26.9	1.2	-19.4	45.1	7.4
10.00	0.070	0.068	5.9	6.2	-0.195	LP_1	3.9	2.2	1.5	63.9	10.3
					-0.195	LP_2	4.6	2.2	9.2	66.7	9.7
					-0.195	LP_A	4.2	1.6	5.5	65.4	7.0
					-1.0	LP_1	-3.0	2.7	-2.8	62.3	14.2
					-1.0	LP_2	-3.0	2.7	7.2	66.0	12.9
					-1.0	LP_A	-3.0	1.9	2.5	64.2	9.6
					-2.0	LP_1	-12.9	3.1	0.1	63.4	17.6
					-2.0	LP_2	-12.8	3.1	4.8	65.1	16.8
					-2.0	LP_A	-12.8	2.2	2.5	64.2	12.2
31.6	0.070	0.070	4.1	3.5	-1.0	LP_1	-4.1	2.4	-8.3	72.0	11.9
					-1.0	LP_2	-6.4	2.4	7.8	76.2	9.9
					-1.0	LP_A	-5.2	1.7	-0.4	74.3	7.6
					-2.0	LP_1	-13.9	1.9	-3.6	73.2	10.1
					-2.0	LP_2	-11.6	1.9	-3.4	73.3	10.3
					-2.0	LP_A	-12.7	1.4	-3.5	73.3	7.2
63.2	0.082	0.079	13.7	2.7	-1.0	LP_1	-0.5	3.0	28.0	38.3	16.5
					-1.0	LP_2	1.7	2.9	-2.0	12.6	23.3
					-1.0	LP_A	0.6	2.1	15.6	27.6	13.6
					-2.0	LP_1	-3.8	3.1	27.8	38.1	19.0
					-2.0	LP_2	0.6	3.0	-24.1	-6.4	32.4
					-2.0	LP_A	-1.5	2.2	8.7	21.7	16.9

n $10^{10}m^{-3}$	Te eV	Ti eV	m_{eff} amu	λ_D mm	V_f V	LP_x	ϵ_{n_I} %	δ_{n_I} %	ϵ_n %	ϵ_{n16} %	δ_n %
1.00	0.156	0.116	8.3	29.4	-0.513	LP_1	-7.8	1.8	-1.1	47.1	9.7
					-0.513	LP_2	-7.4	1.8	-5.3	44.9	10.0
					-0.513	LP_A	-7.6	1.3	-3.1	46.0	7.0
					-1.0	LP_1	-19.6	1.9	-16.4	39.0	11.1
					-1.0	LP_2	-17.7	1.8	-23.3	35.4	11.8
					-1.0	LP_A	-17.7	1.3	-19.8	37.3	8.1
					-2.0	LP_1	-46.0	2.1	-42.5	25.4	14.8
					-2.0	LP_2	-43.9	2.1	-32.7	30.5	14.0
					-2.0	LP_A	-44.9	1.5	-37.5	28.0	10.2
3.16	0.140	0.113	11.4	15.7	-1.0	LP_1	-4.1	2.0	0.5	28.7	13.6
					-1.0	LP_2	-3.2	2.0	6.7	33.1	12.8
					-1.0	LP_A	-3.6	1.4	3.7	30.9	9.3
					-2.0	LP_1	-15.0	2.3	-13.5	18.6	18.6
					-2.0	LP_2	-13.8	2.4	-8.7	22.1	18.1
					-2.0	LP_A	-14.4	1.7	-11.1	20.4	13.0
10.0	0.140	0.112	13.0	8.8	-1.0	LP_1	-1.6	2.6	18.7	33.8	15.8
					-1.0	LP_2	2.0	2.6	15.2	30.9	16.8
					-1.0	LP_A	0. 2	1.8	17.0	32.4	11.5
					-2.0	LP_1	-3.2	2.7	5.7	23.2	20.7
					-2.0	LP_2	-3.4	2.7	14.7	30.4	18.7
					-2.0	LP_A	-3.3	1.9	10.4	27.0	13.9

n $10^{10}m^{-3}$	Te eV	Ti eV	m_{eff} amu	λ_D mm	V_f V	LP_x	ϵ_{n_I} %	δ_{n_I} %	ϵ_n %	ϵ_{n16} %	δ_n %
31.6	0.140	0.089	15.9	5.0	-1.0	LP_1	1.8	2.6	11.8	12.5	19.2
					-1.0	LP_2	0.7	2.6	15.7	16.3	18.3
					-1.0	LP_A	1.2	1.8	13.8	14.4	13.2
					-2.0	LP_1	-1.3	2.4	17.1	17.8	18.8
					-2.0	LP_2	-2.0	2.4	19.1	19.7	18.1
					-2.0	LP_A	-1.7	1.7	18.1	18.7	13.0
3.16	0.210	0.120	12.6	19.2	-1.0	LP_1	-2.5	2.0	11.2	29.2	12.6
					-1.0	LP_2	-2.3	2.0	-1.0	19.6	14.4
					-1.0	LP_A	-2.4	1.4	5.5	24.7	9.5
					-2.0	LP_1	-12.8	2.2	-8.6	13.5	18.2
					-2.0	LP_2	-12.8	2.2	-1.6	19.1	16.9
					-2.0	LP_A	-12.8	1.6	-5.0	16.4	12.4
10.0	0.220	0.107	11.3	11.0	-1.0	LP_1	-0.6	2.2	1.9	30.5	15.0
					-1.0	LP_2	-0.8	2.2	3.0	31.3	14.8
					-1.0	LP_A	-0.7	1.6	2.5	30.9	10.5
					-2.0	LP_1	-5.8	2.7	-0.7	28.6	20.2
					-2.0	LP_2	-5.2	2.6	-5.3	25.4	21.3
					-2.0	LP_A	-5.5	1.9	-2.9	27.0	14.7
10.0	0.280	0.121	16.0	12.4	-1.0	LP_1	2.8	2.3	8.0	8.3	18.5
					-1.0	LP_2	0.8	2.4	23.4	23.6	15.4
					-1.0	LP_A	1.8	1.7	16.4	16.7	11.9
					-2.0	LP_1	-0.5	2.8	1.4	1.6	25.7
					-2.0	LP_2	1.5	2.8	-15.0	-14.7	30.9
					-2.0	LP_A	0.5	2.0	-6.2	-5.9	19.9

Table 22: Relative errors in the inferred density calculated from probe simulations results. $\epsilon_{I_{pic}}$ is the relative error when Eq. 1 is used to infer density. ϵ_n and ϵ_n, correspond to relative error in inferred density when Eq. 5 and 7 are used respectively. δ_{n_I} and δ_n represents the relative uncertainties in their respective inferred densities. Positive errors indicate that calculated density is overestimated while negative signs refer to an underestimation. In all cases, ram velocity is 7673 m/s.

ELECTRON LINEAR AND RETARDATION CURRENTS C05

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3	29.4 mm	7673 m/s	
LP_x	Swarm Bus Included	$\vert\vec{B}\vert$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	No	0	0.196	-45.267	1.2	0.1
LP1	No	0	0.496	-86.456	1.4	0.1
LP1	No	0	-0.168	-6.044	4.3	0.3
LP1	No	0	-0.138	-7.498	4.5	0.3
LP1	No	0	-0.109	-9.214	4.9	0.2
LP1	No	37.6	0.197	-40.871	-9.4	0.1
LP1	No	37.6	0.497	-71.750	-18.9	0.1
LP1	No	37.6	-0.236	-3.615	4.2	0.4
LP1	No	37.6	-0.207	-4.508	4.2	0.3
LP1	No	37.6	-0.178	-5.597	4.5	0.3
LP1	Yes	0	0.186	-36.179	-20.4	0.4
LP2	Yes	0	0.186	-35.535	-22.6	0.4
LPA	Yes	0	0.186	-35.857	-21.5	0.4
LP1	Yes	0	0.485	-72.408	-14.5	0.3
LP2	Yes	0	0.485	-73.237	-13.2	0.3
LPA	Yes	0	0.485	-72.822	-13.9	0.3
LP1	Yes	0	-0.136	-6.872	-10.4	0.8
LP2	Yes	0	-0.136	-6.965	-9.0	0.8
LPA	Yes	0	-0.136	-6.918	-9.7	0.8
LP1	Yes	0	-0.107	-8.577	-8.2	0.7
LP2	Yes	0	-0.107	-8.498	-9.2	0.7
LPA	Yes	0	-0.107	-8.537	-8.7	0.7
LP1	Yes	0	-0.078	-10.332	-9.4	0.6
LP2	Yes	0	-0.078	-10.379	-8.9	0.6
LPA	Yes	0	-0.078	-10.355	-9.2	0.6

Satellite floating potential $V_f = -1$ V.

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3	29.4 mm	7673 m/s	
LP_x	Swarm Bus Included	$\lvert\vec{B}\rvert$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	0	0.186	-24.033	-81.2	1.8
LP2	Yes	0	0.186	-23.920	-82.1	1.8
LPA	Yes	0	0.186	-23.976	-81.6	1.8
LP1	Yes	0	0.485	-51.631	-60.6	1.3
LP2	Yes	0	0.485	-50.668	-63.7	1.3
LPA	Yes	0	0.485	-51.149	-62.1	1.3
LP1	Yes	0	-0.136	-6.018	-26.1	0.9
LP2	Yes	0	-0.136	-6.017	-26.1	0.9
LPA	Yes	0	-0.136	-6.018	-26.1	0.9
LP1	Yes	0	-0.107	-7.173	-29.3	0.8
LP2	Yes	0	-0.107	-7.287	-30.1	0.8
LPA	Yes	0	-0.107	-7.151	-29.7	0.8
LP1	Yes	0	-0.078	-8.404	-34.5	0.7
LP2	Yes	0	-0.078	-8.339	-35.6	0.8
LPA	Yes	0	-0.078	-8.372	-35.0	0.8

Satellite floating potential $V_f = -2$ V.

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3	29.4 mm	7673 m/s	
LP_x	Swarm Bus Included	$\|\vec{B}\|$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	0	0.186	-7.398	-488.7	4.3
LP2	Yes	0	0.186	-7.287	-497.6	4.4
LPA	Yes	0	0.186	-7.342	-493.1	4.3
LP1	Yes	0	0.485	-15.289	-442.4	2.8
LP2	Yes	0	0.485	-14.887	-457.1	2.9
LPA	Yes	0	0.485	-15.088	-449.7	2.8
LP1	Yes	0	-0.136	-2.535	-199.3	2.5
LP2	Yes	0	-0.136	-2.462	-208.3	2.5
LPA	Yes	0	-0.136	-2.498	-203.7	2.5
LP1	Yes	0	-0.107	-2.866	-223.6	2.3
LP2	Yes	0	-0.107	-2.784	-233.2	2.4
LPA	Yes	0	-0.107	-2.825	-228.3	2.4
LP1	Yes	0	-0.078	-3.242	-248.8	2.2
LP2	Yes	0	-0.078	-3.125	-261.7	2.2
LPA	Yes	0	-0.078	-3.183	-255.1	2.2

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	0.156 eV	0.116 eV	8.3	29.4 mm	7673 m/s	
LP_x	Swarm Bus Included	$\lvert\vec{B}\rvert$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	-37.6	0.235	-43.127	-1.3	1.0
LP2	Yes	-37.6	0.235	-40.534	-7.8	1.1
LPA	Yes	-37.6	0.235	-41.830	-4.4	1.0
LP1	Yes	-37.6	0.534	-76.634	-8.4	0.9
LP2	Yes	-37.6	0.534	-73.951	-12.3	0.9
LPA	Yes	-37.6	0.534	-75.293	-10.3	0.9
LP1	Yes	-37.6	-0.171	-5.644	26.0	1.9
LP2	Yes	-37.6	-0.171	-4.888	14.6	2.0
LPA	Yes	-37.6	-0.171	-5.266	20.7	1.9
LP1	Yes	-37.6	-0.142	-7.029	26.5	1.6
LP2	Yes	-37.6	-0.142	-6.031	14.3	1.8
LPA	Yes	-37.6	-0.142	-6.530	20.8	1.7
LP1	Yes	-37.6	-0.113	-8.597	26.0	1.5
LP2	Yes	-37.6	-0.113	-7.366	13.6	1.6
LPA	Yes	-37.6	-0.113	-7.982	20.3	1.6
LP1	Yes	+37.6	0.236	-40.708	-7.3	0.8
LP2	Yes	+37.6	0.236	-40.890	-6.8	0.8
LPA	Yes	+37.6	0.236	-40.799	-7.1	0.8
LP1	Yes	+37.6	0.535	-74.345	-11.7	0.6
LP2	Yes	+37.6	0.535	-75.426	-10.1	0.6
LPA	Yes	+37.6	0.535	-74.886	-10.9	0.6
LP1	Yes	+37.6	-0.154	-5.242	10.3	1.7
LP2	Yes	+37.6	-0.154	-5.912	20.5	1.6
LPA	Yes	+37.6	-0.154	-5.575	15.7	1.7
LP1	Yes	+37.6	-0.125	-6.518	11.0	1.5
LP2	Yes	+37.6	-0.125	-7.574	23.4	1.4
LPA	Yes	+37.6	-0.125	-7.046	17.7	1.4
LP1	Yes	+37.6	-0.096	-8.078	11.8	1.4
LP2	Yes	+37.6	-0.096	-9.342	23.7	1.3
LPA	Yes	+37.6	-0.096	-8.710	18.2	1.3

Satellite floating potential $V_f = -2$ V.

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{10} m^{-3}$	$0.156\ eV$	$0.116\ eV$	8.3	$29.4\ mm$	$7673\ m/s$	
LP_x	Swarm Bus Included	$\lvert\vec{B}\rvert$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	+37.6	-0.136	-2.379	-219.0	3.6
LP2	Yes	+37.6	-0.136	-2.734	-177.5	3.4
LPA	Yes	+37.6	-0.136	-2.556	-196.8	3.5
LP1	Yes	+37.6	-0.107	-2.713	-241.9	3.3
LP2	Yes	+37.6	-0.107	-3.090	-200.1	3.1
LPA	Yes	+37.6	-0.107	-2.902	-219.6	3.2
LP1	Yes	+37.6	-0.078	-2.982	-279.1	3.3
LP2	Yes	+37.6	-0.078	-3.422	-230.4	3.1
LPA	Yes	+37.6	-0.078	-3.202	-253.1	3.2

Table 23: Electron linear and retardation currents calculated from simulations for configuration cases considered. ϵ_{I_p} is the relative error in the calculated current from simulations compared to predicted with OML theory Eq. 2, while δ_{I_p} is the relative uncertainty. Positive errors indicate overestimation while negative signs refer to an underestimation.

ELECTRON LINEAR AND RETARDATION CURRENTS C11

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{11}m^{-3}$	0.280 eV	0.121 eV	16.0	12.4 mm	7673 m/s	

LP_x	Swarm Bus Included	$\lvert\vec{B}\rvert$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	No	0	-0.290	-86.9	2.9	0.3
LP1	No	0	0.010	-274.3	12.2	0.2
LP1	No	0	-0.469	-41.7	1.2	0.4
LP1	No	0	-0.440	-47.1	1.5	0.3
LP1	No	0	-0.411	-53.2	1.7	0.3
LP1	No	37.6	-0.285	-88.4	2.7	0.3
LP1	No	37.6	0.015	-274.4	3.8	0.1
LP1	No	37.6	-0.467	-42.1	1.4	0.3
LP1	No	37.6	-0.438	-47.7	1.8	0.3
LP1	No	37.6	-0.409	-53.7	1.9	0.3
LP1	Yes	0	-0.291	-73.9	-10.7	1.1
LP2	Yes	0	-0.291	-75.1	-9.0	1.1
LPA	Yes	0	-0.291	-74.5	-9.8	1.1
LP1	Yes	0	0.008	-239.1	-4.8	0.6
LP2	Yes	0	0.008	-237.9	-5.3	0.6
LPA	Yes	0	0.008	-238.5	-5.1	0.6
LP1	Yes	0	-0.467	-35.1	-15.3	1.4
LP2	Yes	0	-0.467	-35.6	-13.7	1.4
LPA	Yes	0	-0.467	-35.3	-14.5	1.4
LP1	Yes	0	-0.438	-40.2	-13.6	1.3
LP2	Yes	0	-0.438	-40.2	-13.6	1.4
LPA	Yes	0	-0.438	-40.2	-13.6	1.3
LP1	Yes	0	-0.410	-44.6	-14.8	1.3
LP2	Yes	0	-0.410	-4.0	-11.2	1.3
LPA	Yes	0	-0.410	-45.3	-13.0	1.3

n	Te	T_i	m_{eff}	λ_D	v_d	
$10^{11}m^{-3}$	0.280 eV	0.121 eV	16.0	12.4 mm	7673 m/s	
LP_x	Swarm Bus Included	$\|\vec{B}\|$ μT	V_p V	I_{sim} nA	$\epsilon_{I_{OML}}$ %	$\delta_{I_{sim}}$ %
LP1	Yes	-37.6	-0.213	-104.607	21.5	1.7
LP2	Yes	-37.6	-0.213	-96.506	14.9	1.7
LPA	Yes	-37.6	-0.213	-100.557	18.3	1.7
LP1	Yes	-37.6	0.086	-313.017	19.6	0.9
LP2	Yes	-37.6	0.086	-294.718	14.6	0.9
LPA	Yes	-37.6	0.086	-303.868	17.2	0.9
LP1	Yes	-37.6	-0.395	-48.783	18.5	1.9
LP2	Yes	-37.6	-0.395	-44.561	10.7	1.9
LPA	Yes	-37.6	-0.395	-46.672	14.8	1.9
LP1	Yes	-37.6	-0.365	-55.635	19.3	1.8
LP2	Yes	-37.6	-0.365	-50.284	10.7	1.9
LPA	Yes	-37.6	-0.365	-52.960	15.3	1.8
LP1	Yes	-37.6	-0.336	-63.136	20.0	1.6
LP2	Yes	-37.6	-0.336	-57.028	11.4	1.7
LPA	Yes	-37.6	-0.336	-60.082	15.9	1.7
LP1	Yes	+37.6	-0.210	-94.592	12.8	1.4
LP2	Yes	+37.6	-0.210	-101.242	18.5	1.4
LPA	Yes	+37.6	-0.210	-97.917	15.8	1.4
LP1	Yes	+37.6	0.088	-292.430	14.0	0.9
LP2	Yes	+37.6	0.088	-304.611	17.4	0.8
LPA	Yes	+37.6	0.088	-298.520	15.7	0.8
LP1	Yes	+37.6	-0.388	-42.764	5.4	1.7
LP2	Yes	+37.6	-0.388	-46.757	13.5	1.6
LPA	Yes	+37.6	-0.388	-44.760	9.6	1.6
LP1	Yes	+37.6	-0.359	-48.622	6.2	1.6
LP2	Yes	+37.6	-0.359	-54.105	15.7	1.5
LPA	Yes	+37.6	-0.359	-51.363	11.2	1.5
LP1	Yes	+37.6	-0.330	-55.373	7.3	1.7
LP2	Yes	+37.6	-0.330	-60.972	15.8	1.6
LPA	Yes	+37.6	-0.330	-58.172	11.7	1.7

Table 24: Electron linear and retardation currents calculated from simulations for configuration cases considered. ϵ_{I_p} is the relative error in the calculated current from simulations compared to predicted with OML theory Eq. 2, while δ_{I_p} is the relative uncertainty. Positive errors indicate overestimation while negative signs refer to an underestimation.

n $10^{10}m^{-3}$	T_e eV	T_i eV	m_{eff} amu	λ_D mm	V_f mV	$\|\vec{B}\|$ μT	Swarm	LP_x	ϵ_{T_e} %	δ_{T_e} %
1.00	0.156	0.116	8.3	29.4	-504	0	No	LP1	-3.8	0.5
1.00	0.156	0.116	8.3	29.4	-503	37.6	No	LP1	-1.9	0.7
1.00	0.156	0.116	8.3	29.4	-514	0	Yes	LP1	-1.4	1.0
								LP2	-0.6	1.0
								LPA	-1.0	1.0
1.00	0.156	0.116	8.3	29.4	-1000	0	Yes	LP1	17.1	1.3
								LP2	19.4	1.2
								LPA	18.3	1.2
1.00	0.156	0.116	8.3	29.4	-2000	0	Yes	LP1	43.0	3.9
								LP2	44.6	3.8
								LPA	43.8	3.8
1.00	0.156	0.116	8.3	29.4	-466	-37.6	Yes	LP1	-4.1	1.8
								LP2	0.0	1.6
								LPA	-2.2	1.7
1.00	0.156	0.116	8.3	29.4	-465	+37.6	Yes	LP1	-7.2	1.7
								LP2	-12.4	1.9
								LPA	-10.0	1.8
1.00	0.156	0.116	8.3	29.4	-2000	+37.6	Yes	LP1	49.1	4.5
								LP2	47.6	4.7
								LPA	48.3	4.6
10.0	0.280	0.121	16.0	12.4	-990	0	No	LP1	-2.7	1.0
10.0	0.280	0.121	16.0	12.4	-985	37.6	No	LP1	-2.3	1.0
10.0	0.280	0.121	16.0	12.4	-990	0	Yes	LP1	3.2	2.0
								LP2	-8.9	2.3
								LPA	-2.8	2.2
10.0	0.280	0.121	16.0	12.4	-913	-37.6	Yes	LP1	-10.8	2.0
								LP2	-7.1	1.9
								LPA	-9.0	2.0
10.0	0.280	0.121	16.0	12.4	-911	+37.6	Yes	LP1	-9.7	2.0
								LP2	-14.4	2.1
								LPA	-12.1	2.1

Table 25: Relative errors in the inferred electron temperature from probe currents calculated from simulations. Two cases of plasma parameters are considered, whereas, the inclusion and orientation of a background magnetic field, as well as the presence of the Swarm satellite have been varied in both cases. The relative errors in the inferred electron temperature calculated from Eq. 8, are labeled as ϵ_{T_e}, while δ_{T_e} is the relative uncertainty in the estimated temperature. Positive errors indicate overestimation while negative signs refer to an underestimation. In all cases the drifting plasma speed is equal to the satellite ram velocity, $v_\perp = 7673\ m/s$.