New model for the ion collection by cylindrical probes over a wide range of collisionality

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Langmuir probes remain one of the most important diagnostic tools for plasma processing applications. To accurately determine the electron density, it has become customary to rely on the electron current part of the Langmuir probe characteristic using the Druyvesteyn method. However, in cases where no reference electrode for the plasma is available, double probes need to be employed to perform the measurements. Such double probes rely on the ion current collected by the probe to determine the ion density. However, the relationship between ion density and current is strongly affected by ion-neutral collisions, as is illustrated in figure 1.

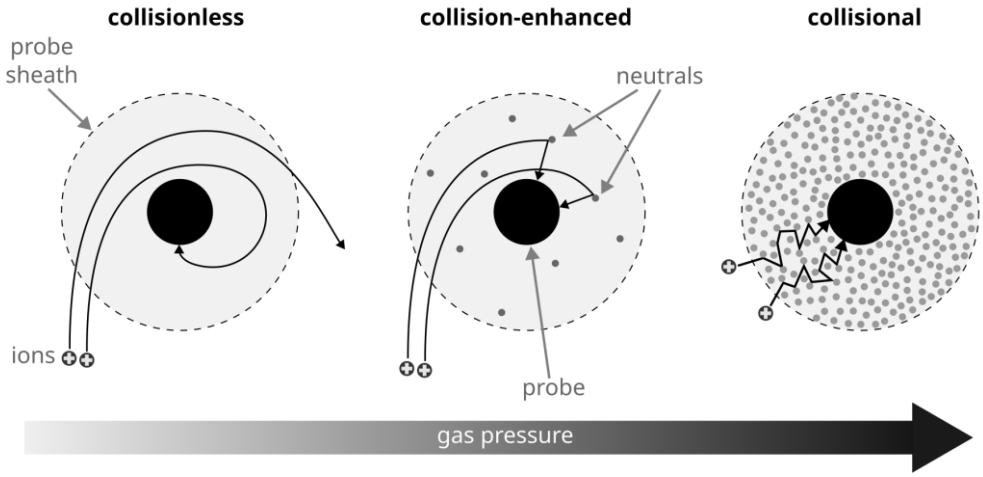

Figure 1: Effect of changing collisionality on the ion movement close to a Langmuir probe.

Even at low pressures of a few Pa, the ion current is affected by collisions due to the large cross section for charge exchange. Available theories for collisional or collision-enhanced ion currents onto probes are complex, not well validated, and often only suitable for a certain range of probe sheath thickness or collisionality. Thus, in this contribution, we compare available collisional probe theories for the ion collection by a probe immersed in a plasma to particle-in-cell (PIC) simulations. Using these results, we propose a simpler and more intuitive model for the ion current collected by the probe, based on the model of Gatti and Kortshagen (Phys. Rev. E 78, 046402, 2008), developed for the charging of dust particles.

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