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Increased Upstream Ionization Due to Spontaneous Formation of a Double Layer in an Expanding Plasma¹

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We report observations that confirm a theoretical prediction that formation of a current-free double layer in a plasma expanding into a chamber of larger diameter is accompanied by an increase in ionization upstream of the double layer. The theoretical model argues that the increased ionization is needed to balance the difference in diffusive losses upstream and downstream of the expansion region. In our expanding helicon source, we find that the upstream plasma density increases sharply at the same driving frequency at which a double layer appears. For driving frequencies at which no double layer appears, large electrostatic instabilities are observed. Time resolved laser induced fluorescence and electrostatic probe measurements suggest that the double layer initially forms for all driving frequencies. However, for particularly strong double layers, the instability appears early in the discharge and disrupts the double layer. The double layer is identified in this work through observations of an acceleration population of ions downstream of the plasma source.

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