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Double Layers in the expanding region of electronegative plasmas

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Double layers (DLs) have been studied over the past decades theoretically, numerically and experimentally (see the review by Raadu in Physics Report 178, 25 1989, and references therein). The biggest part of the literature treats the case of electropositive plasmas, however, DLs were also found in electronegative plasmas (both theoretically and experimentally). Recently, Charles and co-workers (Appl. Phys. Lett. 82, 1356, 2003) have observed a current-free DL in the expanding region of a helicon wave excited plasma at very low pressures (typically less than a millitorr). A strongly diverging static magnetic field seemed to be required in order to reach the conditions for double layer formation. Their system also had an abrupt change in radius at the boundary between the source and the diffusion chambers, which could possibly be a source of DL formation. Following this work, we have observed and studied double layers in a system of similar geometry but without B field and with electronegative gas mixtures. The DL's were not observed in pure argon. They seem to have a spherical shape and be formed at the boundary between the source and the diffusion chambers. They act as an internal boundary between a high electron density, high electron temperature, low electronegativity plasma upstream, and a low electron density, low electron temperature, high electronegativity plasma downstream. They are only stable for a small window of electronegativity. In most of the parameter space explored, they periodically form at the interface between the two chambers and they propagate at low speed (about 150 m/s) in the expanding chamber. We measured their amplitude and their dynamics by space and time-resolved langmuir probe experiments. Some explanations for their formation and propagation will be given.