Motivation

Ion velocity distribution functions (ivdfs) are investigated by laser induced fluorescence in Ar-Xe and Ar-He plasmas. We explore the influence of helium addition both as a function of its density and a function of its position in the plasma expansion. At the end of the source the argon ivdf shows a bimodal structure indicative of an electric double layer (EDL) upstream of the measurement location. The fast argon ion component parallel velocity increases with Xe fraction from 6.7 to 8 km/s as the Xe fraction increases from 0 to 4%. In the expansion region, the bimodal character of Ar+ is maintained with a supersonic fast component reaching parallel speeds of 10.5 km/s. For all studied plasma conditions and different spatial locations, the Xe+ ivdf exhibits a unimodal structure with a maximum ion flow velocity of 2.2 km/s at the end of the source. For Ar+ plasmas, the Ar+ ivdf is bimodal with the fast ion component parallel velocity increasing from 5.2 to 7.8 km/s as the He fraction increases from 0 to 30%. For the same He fraction, the slow argon ion population distribution changes from a single Gaussian to a wide distribution extending all the way from the speed of the fast population to 0 m/s.

Experimental Apparatus

(a) HELIX magnets
(b) LEIA magnets
(c) Magnetic Field gradient and magnitude, and magnetic field gradient versus axial position over the entire length of HELIX-LEIA system. (c) Contraction of constant magnetic flux showing the increasing divergence that results when the magnetic field in the expansion region decreases from 79 G (dashed line) to 14 G (solid line) for a constant source field of 600 G.

Parameters for Two-Species Plasmas

(b) Parallel ion flow speeds in HELIX at z = 10 G. (c) Helium fraction versus argon fraction, respectively. Also shown in (b) are the Xe+ (solid line) and system (dotted line) sound speeds based on measurements at z = 126 cm.

LIF Measurements in Two-Species Plasmas

(a) Individual ion sound speeds (circles for Ar+ and triangles for Xe) and the system sound speed (squares) as function of xenon fraction in HELIX at z = 126 cm. (b) Parallel ion flow speeds in HELIX at z = 126 cm versus xenon fraction (same symbol as above).

Effect of increasing helium fraction on the Ar+ parallel ivdf in HELIX. Measurements were obtained at z = 126 cm.