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The dynamics of blob merging in the tokamak scrape-off layer region

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Blobs [1,2] are high-density coherent structures in the edge and scrape-off layer (SOL) regions of a tokamak plasma that are believed to contribute to anomalous plasma transport. The interactions among blobs can modify their dynamics such as their radial velocities, current density, and magnetic field perturbations. In this work, we have studied the merging of two blobs in the SOL region using a two-dimensional (2D) electromagnetic fluid model that is solved numerically using the BOUT++ framework [3]. Since the currents in two adjoining blob filaments flow in the same direction, the magnetic field that exists between each pair is directed in opposite directions; as a result, when two filaments interact with one another, the magnetic fields between them overlap to create a situation that is analogous to that of the "coalescence instability" of two magnetic islands [4].

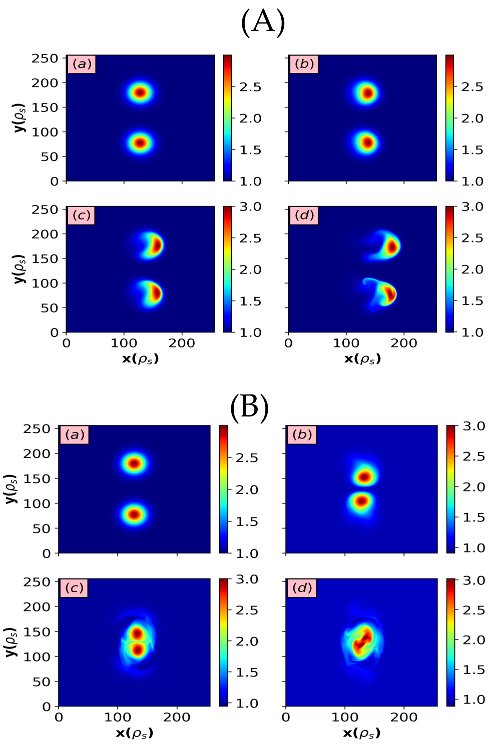

Fig.1: Time evolution of blobs for different current density. (A) $J_0 = 0.8$ MA/m^2 and (B) $J_0 = 4.8$ MA/m^2.

We study the dynamics of blob merging in such a scenario by further taking into account the finiteness of toroidal curvature that is important in the SOL region as well as the presence of a non-uniform background plasma density. The interplay of the coalescence instability, curvature effects and density inhomogeneity produce interesting results such as the mutual spiraling of the blobs as they approach each other. The blob rotation frequency is measured as a function of the density inhomogeneity. The conditions for the spiraling motion are also delineated. A pictorial display of the dynamics of two plasma blobs for different values of their initial current densities(J_0) is shown in Fig.1(A)-(B). Fig.1(A) shows that when J_0 is lower, the blobs move independently in a mushroom shape along the radial direction. This is because the ExB velocity is caused by charge separation from the grad-B and the curvature drifts. However, when J_0 is increased, the blobs merge rapidly due to the prevailing attractive force caused by the coalescence instability. No dominant role of effective gravity (curvature effect) is found for large J_0. The dynamics of the center of mass position of each blob has also been investigated and will be presented. The decreases in the radial motion of the blob due to different curvatures of the magnetic field will also be discussed to provide a consolidated picture of blob merging.

References

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