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Conceptual Study of Possibility for Droplets to Achieve Superheated in Edge Tokamak Plasmas

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Molten droplets are probably generated in a fusion tokamak through splashing of molten layers of plasma-facing surfaces, during transient events such as disruptions and edge localized modes (ELMs) at which surface melting is unavoidable, and melting of solid wall-material debris, i.e. dust/flakes, by heat flux of an energetic fusion plasma. Molten droplets are allowed if plasma-facing materials are made of metals except carbon (C). As ITER is now planning to use tungsten (W) for its divertor and beryllium (Be) for its main wall, dust and droplets should mostly consist of both wall materials. As mentioned that a fusion plasma is so energetic, it is possible to have droplets staying in the plasma long enough before a fusion operation terminates. The assumption is strengthen by the existences of many spherical dust, caused by surface tension of liquid phase. This suggests that to study metallic dust transport, some phenomena occurring especially in liquid phase should be focused on. By adapting the derivation of floating potential determination, such as Orbital Motion Limited (OML) theory, we are permitted to determine ion and electron momentum fluxes. This results in actual pressures on dust and droplet in a plasma. Moreover, net pressure on a droplet does matter because it determines boiling temperature of the droplet materials. This should influence on behaviors of dust/droplet transport in tokamaks. We conduct this preliminary study to consider whether or not superheating by depressurization can be achieved on a droplet in a fusion plasma. We believe superheating should occur if a droplet encounters steep number density and temperature profiles in tokamaks, i.e. edge transport barrier in H-mode. If such steep plasma profiles allow droplet superheating, this should suggest further effects, for example localized impurity deposition by electrostatically-enhanced vapor explosion, superheating rocket force for abnormal high speed droplet etc., which should be never found for non-liquid C dust.

Keywords: misty plasma, plasma-surface interactions, dust, tokamak, Orbital Motion Limited (OML), Edge Localized Modes (ELMs), disruption, superheating.

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