Plasma jets stabilize water to splash less

Wonho Choe[1], Sanghoo Park, Hyungyu Lee[1], Joo Young Park[1], Jinwoo Kim[1], Se Youn Moon[2], Uroš Cvelbar[3]

[1] *Korea Advanced Institute of Science and Technology, Daejeon, Republic of Korea*

[2] *Chonbuk National University, Jeonju, Republic of Korea*

[3] *Jožef Stefan Institute, Ljubljana, Slovenia*

Historically, boundary physics has been crucial in understanding a diverse range of phenomena prevalent in nature and in creating highly unusual processes. A good example is the cavity produced by blowing air through a straw directly above a cup of water. One longstanding issue is the hydrodynamic stability of such gas–liquid systems, where some attention has been given to the formation of gas-blown cavities. However, little attention has been given to the stability of gas-blown cavities, i.e., how the interface is deformed and destabilized remains unknown, and currently such incomplete understanding limits its practical usage. In our recent work (Nature 592 (2021), 49), the stabilization of such instabilities by weakly ionized atmospheric pressure plasma for the case of a gas jet impinging on water is demonstrated, based on shadowgraph experiments and computational two-phase fluid and plasma modeling. We focus on the interfacial dynamics relevant to electrohydrodynamic (EHD) gas flow, so-called electric wind, occurring inside the plasma which is induced by the momentum transfer from accelerated charged particles to neutral gas under an electric field (Nature Comm. 9 (2018) 371). A weakly ionized plasma consisting of periodic pulsed ionization waves, called plasma bullets, exerts more force via electrohydrodynamic flow on the water surface than a neutral gas jet alone, resulting in cavity expansion without destabilization. Furthermore, both the bidirectional electrohydrodynamic gas flow and electric field parallel to the gas–water interface produced by plasma interacting 'in the cavity' render the surface more stable. This case study demonstrates the dynamics of liquids subjected to a plasma-induced force, offering insights into physical processes and revealing an interdependence between weakly ionized plasma and deformable dielectric matter, including plasma–liquid systems.