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Title
Study of the interaction between a droplet and acoustic waves

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Abstract
The interaction between a droplet mist and an acoustic wave is observed in many situations. For applications interesting rocket propulsion, this interaction can be observed in the combustion chamber at the level of liquid propellant injectors and with the aluminum droplets created during the pyrolysis of propellants for solid rocket engines. It can also be found on the outside of the rocket during takeoff with the water deluge, which is used to reduce the heat flux undergone by the launch pad and to attenuate the acoustic environment to protect both the payload and the launcher. Due to the complexity of the flows and the multiple interactions, we need to use numerical simulations to ensure the physical integrity of critical elements on the launchpad. These are mainly based on steady or quasi-steady models of heat and mass transfer between the droplet mist and the surrounding gas undergoing the acoustic wave. These models are generally developed in the framework of a single isolated droplet in linear acoustics. However, during the lift-off of a launcher like Ariane 5, sound pressure level up to 0,2 bar (180 dB) are encountered, which does not meet this condition. So in order to determine models that do not follow these assumptions we must start again from the terms of exchange at the droplet level. Knowing that the mists are modeled as a set of independent droplets, we will express the terms of exchanges of momentum, energy and mass between a droplet and an acoustic wave. We will use an original, conservative, overlapping mesh method available in the Onera Cedre code and an approach of increasing complexity.

Figure 1: Water deluge during the lift-off of Artemis 1

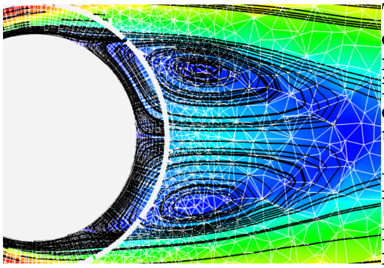
Figure 2: Streamline at Re = 188

The principle of the numerical method is to go from two meshes to a single dynamic mesh, by cutting the background mesh, which will be used as reference for the calculation, by a smaller mesh. This method allows us to integrate forces on the surface of the spherical droplet and to compute its displacement depending on these forces in a galilean reference frame in a two-way coupling.

In this work we will check the performance of the method in a Stokes flow by comparing the drag of the spherical droplet with the experimental drag find in Clift et al. ([1]). Once we have measured the uncertainties of the method, we will validate its behavior in a laminar flow by computing the drag of the droplet at various Reynolds number. We will compare our numerical simulations in linear acoustic with drag's formulas find by Dodemand [2] and Abbad [3]. This step will be used to decide a numerical configuration that will be used with acoustic perturbation to quantified how frequencies and amplitude of this acoustic wave impact the droplet's drag.

References
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