Discovery in Fragmentation

Date : Feb. 22, 2016
Place : 12th bldg., School of Eng., University of Tokyo
http://www.rocketlab.t.u-tokyo.ac.jp/contact

10:00-11:30

Emmanuel Villermaux (irphe)

"Dense Spray Evaporation as a Mixing Process'"

We explore the processes by which a dense set of small liquid droplets (a spray) evaporates in a dry, stirred gas phase. A dense spray of micron-sized liquid (water or ethanol) droplets is formed in air by a pneumatic atomizer in a closed chamber. The spray is conveyed in ambient air as a plume whose extension depends on the relative humidity of the diluting medium. Standard shear instabilities develop at the plume edge, forming the stretched lamellar structures familiar with passive scalars. Unlike passive scalars however, these lamellae vanish in a finite time, because individual droplets evaporate at their border in contact with the dry environment. Experiments demonstrate that the lifetime of an individual droplet embedded in a lamella is much larger than expected from the usual *d-squared* law describing the fate of a single drop evaporating in a quiescent environment. By analogy with the way mixing times are understood from the convection-diffusion equation for passive scalars, we show that the lifetime of a spray lamellae stretched at a constant rate γ is

$$t_v = \frac{1}{\gamma}\ln\left(\frac{1+\phi}{\phi}\right)$$

where ϕ is a parameter which incorporates the thermodynamic and diffusional properties of the vapor in the diluting phase. The case of time-dependent stretching rates is examined too. A dense spray behaves almost as a (not conserved) passive scalar.

13:00-14:00

Takao Inamura (Hirosaki University)

"Formation of Upwash by Liquid Jets Impingement"

The liquid sheet breakup type of airblast atomizer, such as splash plate atomizer, can utilize efficiently the kinetic energy of atomizing air stream for the liquid atomization. Thus, the fine droplets can be easily obtained even at low liquid injection pressure. In order to increase the liquid flowrate without the increase of injection pressure on the splash plate atomizer, the number of an impinging jet should be increased. By this way, the interference between the liquid sheets on the impingement plate generated by the impingement of adjacent liquid jets occurs, and the upwash is generated. The upwash formation influences the spray characteristics for this type of atomizer. The present study aims to predict the formation condition and the shape of an upwash by the theoretical analysis. Firstly, the theoretical analysis to predict the upwash shape was deduced by applying the theoretical analysis of the film flow on the splash plate. Secondary, the experiments were carried out to classify the upwash flow pattern and to clarify the formation condition and the characteristics of an upwash. And finally, the reliability of a theoretical analysis was verified by the experiments.

14:00-15:00

Nobuyuki Kawahara (Okayama University)

"Interaction between laser-induced plasma and transient fuel spray"

The behaviors of laser-induced plasma and fuel spray were investigated by visualizing images with an ultra-high-speed camera. Timeseries images of laser-induced plasma in a transient spray were visualized using a high-speed color camera. The effects of a shockwave generated from the laser-induced plasma on the evaporated spray behavior were investigated. The interaction between a single droplet and the laser-induced plasma was investigated using a single droplet levitated by an ultrasonic levitator. Two main conclusions were drawn from these experiments: (1) the fuel droplets in the spray were dispersed by the shockwave generated from the laser-induced plasma; and (2) the plasma position may have shifted due to breakdown of the droplet surface and the lens effect of droplets.

15:30-16:30

Hiroshi Yamasaki (Nihon University)

"Disruptive Burning of Multi-Component Fuel Droplet"

Disruptive burning processes of multi-component fuel droplet which composed with different boiling points are reviewed. The focus is mainly paid on the fundamental mechanism relevant to the micro-explosion phenomena of miscible or immiscible multi-component fuel droplet combustion which is not common to the combustion of pure fuel. Described at first are the kinetic model and the probability model for predicting the nucleation of vapor bubbles in the liquid phase. The evaporation and the combustion of miscible or immiscible fuel mixture droplet are among the primary subjects. Discussed are the phenomenological burning processes, the burning rate constant, the flame phenomena in the droplet combustion. Also mentioned are the in-droplet transfer processes including the phase separation, the micro-explosion phenomena, and the conditions for the micro-explosion to occur and the empirical equation for the rate of micro-explosion based on the probability model.

16:30-17:30

Chihiro Inoue (University of Tokyo)

"Time Scale in Successive Fragmentation"

Fragmentation in general leads to stabilize the states of split pieces quickly, which indicates the breakup number of times is limited just once or twice for a single droplet or a solid piece. Unlike the usual fragmentation, we find a unique phenomenon, ten-times successive fragmentation of a single droplet. When a droplet is non-evaporative and the thermal decomposition drives micro-explosion, the phenomenon occurs involving inertia, visco-capillarity and thermal/molecular diffusion of multiphase flow. Individual process of the fragmentation cascade is clarified and two dominant time scales are found. Thermal diffusion time is required before nucleation to heat up the droplet by exothermic surface reaction. Then, a single bubble grows inside and the droplet bursts to produce daughter droplets following the capillary time scale. By integrating the individual time scale, full cycle of the successive fragmentation is given by a formulation by which the calculated values agree well with experimental results.