Karlsruher Institut für Technologie

Institut für Mechanik (IFM)
Prof. Dr.-Ing. Peter Betsch
Prof. Dr.-Ing. Thomas Seelig

Institut für Hydromechanik (IfH)
Prof. Dr.-Ing. Markus Uhlmann

Institut für Strömungsmechanik (ISTM)
Prof. Dr.-Ing. Bettina Frohnapfel

Institut für Technische Mechanik (ITM)
Prof. Dr.-Ing. Thomas Böhlke
Prof. Dr.-Ing. Alexander Fidlin
Prof. Dr.-Ing. Carsten Proppe

Mechanics Colloquium

Referent:	Dr. Alberto Vela-Martín / ZARM University of Bremen
Datum:	15.12.2022
Uhrzeit:	15:45 – 17:15 Uhr
Ort:	10.81 Emil Mosonyi-Hörsaal (HS 62)
Titel:	**CAUSALITY-BASED MODELLING OF DROP BREAKUP IN TURBULENCE**

Abstract

The dynamics of inmiscible binary mixtures in the presence of turbulence is largely controlled by the breakup of fluid particles, which needs to be accurately modelled to predict the evolution of these flow. This, however, remains a challenge due to our poor understating of the mechanisms that cause turbulent breakup. In this talk, causality-based models of drop breakup will be presented that accurately reproduce the probability of drop breakup in homogeneous isotropic turbulence.
A novel GPU code is used to perform thousands of independent direct numerical simulations of single drops at different Weber numbers. This extensive database is used to fully characterise the statistics of the breakup process for drops in mixtures of equal density. It will be shown that, for Weber numbers close to the Hinze diameter [1], the breakup of single drops resembles a memoryless statistical process characterised by a single parameter, the breakup rate. This quantity depends exponentially on the inverse of the Weber number, but not on the Reynolds number of the drop or the ratio of the carrier to the disperse phase viscosities.
To explain these results, breakup is analysed from an energetic perspective and in light of recent findings on the mechanisms that cause the increments of the surface energy [2]. Causal analysis is applied to the deformation of drops to show that breakup is driven by the stretching of the drop surface by eddies far from the drop, whereas the interactions between the surface of the drop and eddies close to it provide only a ‘passive’ dissipation mechanism. This causal picture is used to construct two models based on extreme-value theory and random walks on the surface-energy

space, which reproduce the memoryless statistics of breakup and the scaling of the breakup rate observed in our simulations. These models could be extended to different material properties of the fluid-fluid mixture (bubbles or very viscous drops), and suggest that the breakup of drops at low Weber numbers could be caused either through an accumulative process or by the interaction of the drop with the most extreme events in the flow. An important implication of these results is that the breakup probability decreases exponentially with decreasing Weber, but may be non-zero below the maximum stable diameter given by Hinze [1], challenging the established paradigm of turbulent drop breakup.

______

References:

[1] Hinze, J.O., AIChE 3, 289–295 (1955).
[2] Vela-Martin, A, Avila, M, J. Fluid Mech. 929 (2021).

You are cordially invited to take part in the event.

Prof. Dr. Markus Uhlmann