Regular and Irregular Splashing of Drops on Geometric Targets

Gabriel Juarez  
*University of Pennsylvania*

Thomai Gastopoulos  
*University of Pennsylvania*

Yibin Zhang  
*University of Pennsylvania*

Michael L. Siegel  
*University of Pennsylvania*

Paulo E. Arratia  
*University of Pennsylvania*, parratia@seas.upenn.edu

Follow this and additional works at: [https://repository.upenn.edu/meam_papers](https://repository.upenn.edu/meam_papers)

Part of the [Mechanical Engineering Commons](https://repository.upenn.edu/meam_papers)

**Recommended Citation**

Juarez, Gabriel; Gastopoulos, Thomai; Zhang, Yibin; Siegel, Michael L.; and Arratia, Paulo E., "Regular and Irregular Splashing of Drops on Geometric Targets" (2012). *Departmental Papers (MEAM)*. 295.  
[https://repository.upenn.edu/meam_papers/295](https://repository.upenn.edu/meam_papers/295)


Copyright 2012 American Institute of Physics. This article may be downloaded for personal use only. Any other use requires prior permission of the author and the American Institute of Physics.

This paper is posted at ScholarlyCommons. [https://repository.upenn.edu/meam_papers/295](https://repository.upenn.edu/meam_papers/295)  
For more information, please contact repository@pobox.upenn.edu.
Regular and Irregular Splashing of Drops on Geometric Targets

Abstract
The effect of target cross-sectional geometry on drop splashing is investigated using surfaces with length scales comparable to the drop diameter. The target cross-sectional geometries are regular polygon shapes that vary from a triangle ($n = 3$) to a decagon ($n = 10$), where $n$ is the number vertices. The impacting cross-sectional surface area of all targets is constrained to equal the cross-sectional area of the impacting drop which is 6.38 mm$^2$.

Disciplines
Mechanical Engineering

Comments

Copyright 2012 American Institute of Physics. This article may be downloaded for personal use only. Any other use requires prior permission of the author and the American Institute of Physics.
The effect of target cross-sectional geometry on drop splashing is investigated using surfaces with length scales comparable to the drop diameter. The target cross-sectional geometries are regular polygon shapes that vary from a triangle \((n = 3)\) up to a decagon \((n = 10)\), where \(n\) is the number of vertices, a transition from regular \((3 \leq n < 8)\) to irregular \((n \geq 8)\) splashing occurs. (Top row) At maximum expansion, for \(3 \leq n < 8\), geometrically shaped lamella that are azimuthally rotated by \(\pi/n\) with respect to the target orientation are observed. For \(n \geq 8\), the lamella shapes are independent of target cross section. (Bottom row) The breakup of lamella into filaments is controlled for \(3 \leq n < 8\), as the number and location of filaments is equal to \(n\) and are spaced apart by \(\pi/n\), respectively. Lamella breakup for \(n \geq 8\), however, is irregular and independent of target cross section.

**Regular and irregular splashing of drops on geometric targets**

Gabriel Juarez, Thomai Gastopoulos, Yibin Zhang, Michael L. Siegel, and Paulo E. Arratia

Department of Mechanical Engineering and Applied Mechanics, University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA

(Received 3 August 2012; published online 17 September 2012)

[http://dx.doi.org/10.1063/1.4747159]

The effect of target cross-sectional geometry on drop splashing is investigated using surfaces with length scales comparable to the drop diameter. The target cross-sectional geometries are regular polygon shapes that vary from a triangle \((n = 3)\) to a decagon \((n = 10)\), where \(n\) is the number of vertices. The impacting cross-sectional surface area of all targets is constrained to equal the cross-sectional area of the impacting drop which is 6.38 mm².

In our experiments, liquid drops with a diameter \(D\) of 2.85 mm fall from a height of 15 cm before colliding with the target surfaces. Drops impact the targets with a measured velocity \(U\) of 1.56 m/s. The liquid drops are a mixture of de-ionized water and glycerol and have a viscosity \(\mu\) of 10 cP and a surface tension \(\gamma\) of 35.3 dyn/cm. The resulting Reynolds number \((\text{Re} = \rho DU/\mu)\) is 550 and the Weber number \((\text{We} = \rho DU^2/\gamma)\) is 250. Images from above the targets are recorded using high-speed photography at 40,000 frames per second.

Figure 1 shows example snapshots from the top view of drops colliding with different geometric targets. As the target cross-sectional geometry is varied, we observe a transition from regular \((3 \leq n < 8)\) to irregular \((n \geq 8)\) splashing. The top row of Fig. 1 shows liquid lamella moments after impact as the outer rim reaches its maximum value during radial expansion. For \(3 \leq n < 8\),
the observed lamella shapes are identical to the geometric target but are azimuthally rotated by \( \pi/n \) with respect to the target vertices. This is due to the azimuthal variation of viscous dissipation along the target surface. For \( n \geq 8 \), the lamella do not resemble geometric shapes and are independent of target cross section. The bottom row of Fig. 1 shows the subsequent breakup of liquid lamella into secondary filaments. For \( 3 \leq n < 8 \), the geometrically shaped lamella undergo a regular breakup into \( n \) filaments that are azimuthally spaced apart by \( \pi/n \). For \( n \geq 8 \), however, the lamella undergo an irregular breakup as the number and location of filaments is governed by the most unstable Plateau-Rayleigh mode rather than the target geometry.\(^1\)

This work was supported by the National Science Foundation through the award CBET-0932449.