GRAZ UNIVERSITY OF TECHNOLOGY
INSTITUTE OF FLUID MECHANICS AND HEAT TRANSFER

Setting up the cases for viscous drop oscillations

Author: *Dino Zrnić*

Supervisor: Univ.-Prof. Dr.-Ing. habil. G. Brenn

Date: *November 5th, 2021*

1. Initial drop suface

The drop is considered axisymmetric as shown in the figure 1. We consider three initial modes of deformation shown in the figure 2. The initial deformation is governed by a Legendre polynomial of degree m with the deformation amplitude η_0. The radial

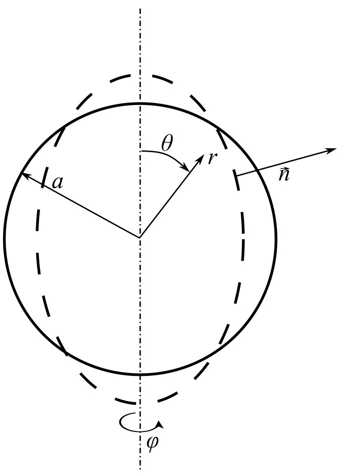

Figure 1: Sketch of the geometry of a liquid drop under deformation at mode 2.

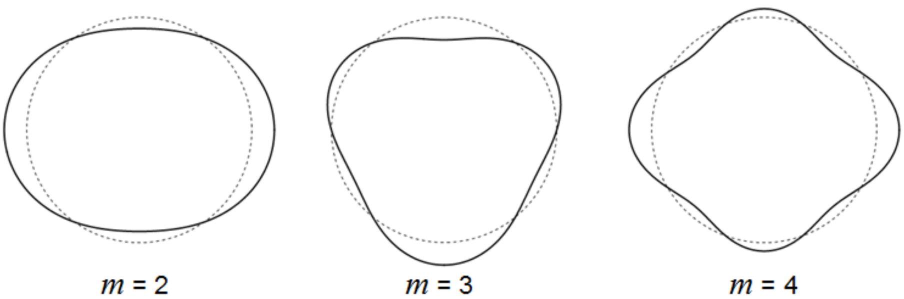

Figure 2: Sketch of a liquid drop under deformation at mode 2, 3 and 4.

position of the drop surface deformation at initial time writes

$$r_s(\theta,0) = 1 + \eta_0 P_m(\cos\theta) - \eta_0^2 \frac{1}{2m+1} - \frac{\eta_0^3}{6}\int_{-1}^{1} P_m(\cos\theta)^3 d(\cos\theta) \mp \dots \quad (1)$$

We can write it in specific form for the various cases

$$r_s(\theta,0) = A + \eta_0 P_m(\cos\theta) \quad (2)$$

and with the data in table 1 depict the initial shape of the drop.

Cases	m	Oh	η_0	A
1.	2	0.1	0.4	0.966781
2.	3	0.1	0.4	0.977143
3.	4	0.1	0.4	0.981839
4.	2	0.1	0.2	0.991848
5.	4	0.56	0.05	0.999721

Table 1: Initial mode of deformation, Ohnesorge number and coefficients for drop surface position along polar angle for different cases. The values are non-dimensionsional.

The positions of the deformed surface along the polar angle are stored in the separate folder numbered with the respective case. For the first case data is named "sufaceDropCase1.txt" and placed under the folder "Case1". The same analogy follows for other cases. Data for the deformed drop surface is given for θ between 0 and π.

2. Initial velocity fields

The velocity solutions consist of large number of terms and therefore the expressions for the velocity fields will not be given. Instead, we give the values of the radial and polar velocity at the various positions inside the drop i. e., velocities in radial and polar direction are given in range of θ between 0 and π, and radius between 0 and $r_s(\theta, 0)$.

The related data for radial and polar velocity is given in the folder of the corresponding cases e. g., for the first case in table 1 radial and polar velocity is named as "radialVelCase1.txt" and "polarVelCase1.txt", respectively.

An example of the first three rows in the "radialVelCase1.txt" is given in the table 2. First two columns depict the position inside drop (radial and polar position) and third gives the value of the radial velocity component for corresponding position. The same analogy is given for polar velocity and follows for all cases in table 1. The values are in the non dimensional form.

$r[-]$	$\theta[rad]$	$u_r[-]$
0.1	0.01	0.03358921823934715
0.2	0.01	0.06565005541886992
0.3	0.01	0.09441014717731866
...	...	...

Table 2: Example of first three rows in file "radialVelCase1.txt".

The solutions of the radial velocity have singularities at $r = 0$ and for polar velocity at all radial positions along $\theta = 0°$ and $\theta = 180°$. These positions are avoided in the calculations.