

What happens before the impact of a disc on water?

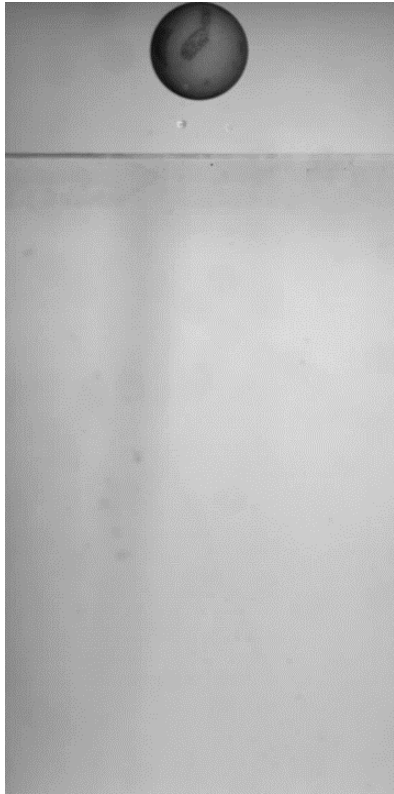
An experimental investigation

Utkarsh Jain, Anaïs Gauthier, Devaraj van der Meer & Detlef Lohse

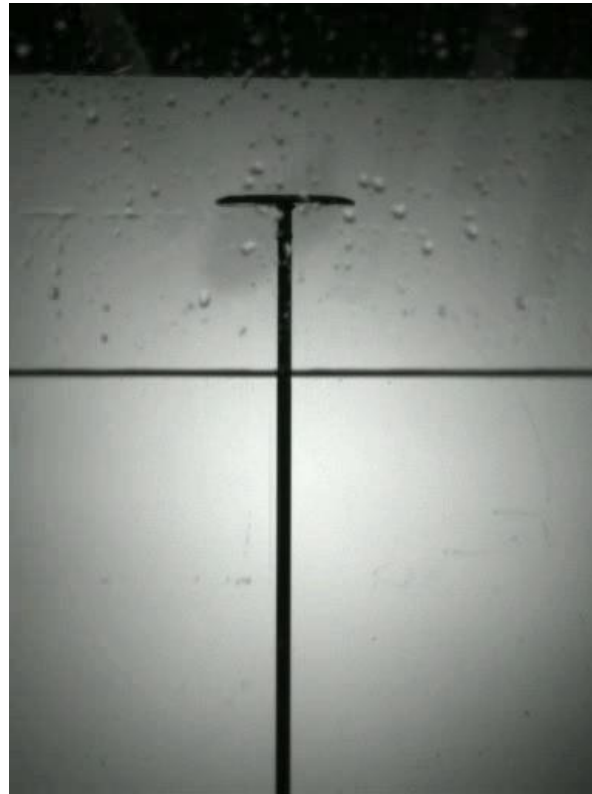


Oct 2017 – Multiphase workshop, Paris

Water entry

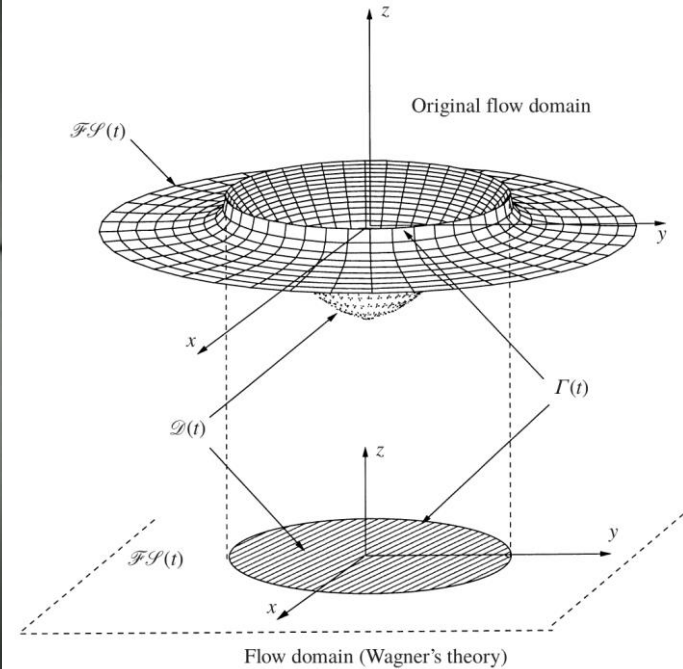


Truscott et al. (2014)
Ann. Rev. of Fluid Mech.



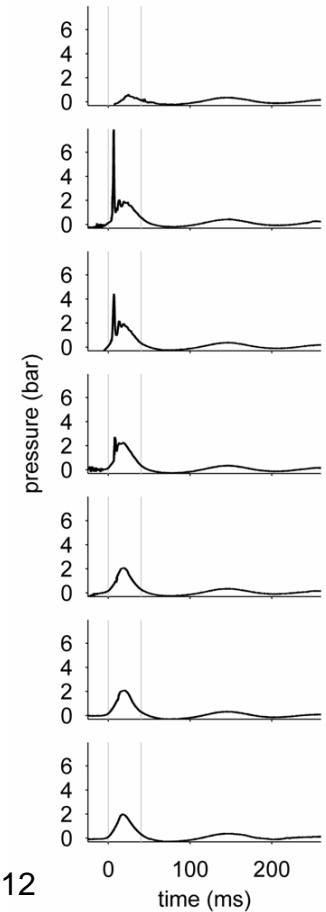
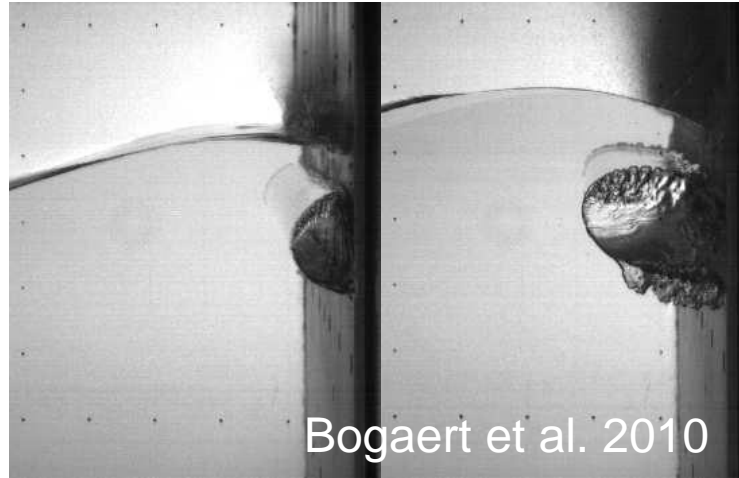
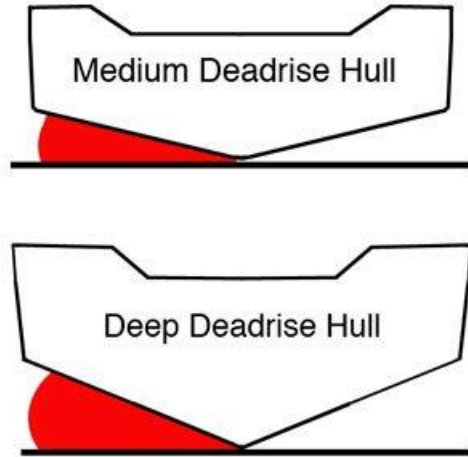
Bergmann et al. (2009) JFM

Wagner problem and several modifications of it



Korobkin (2001) JFM

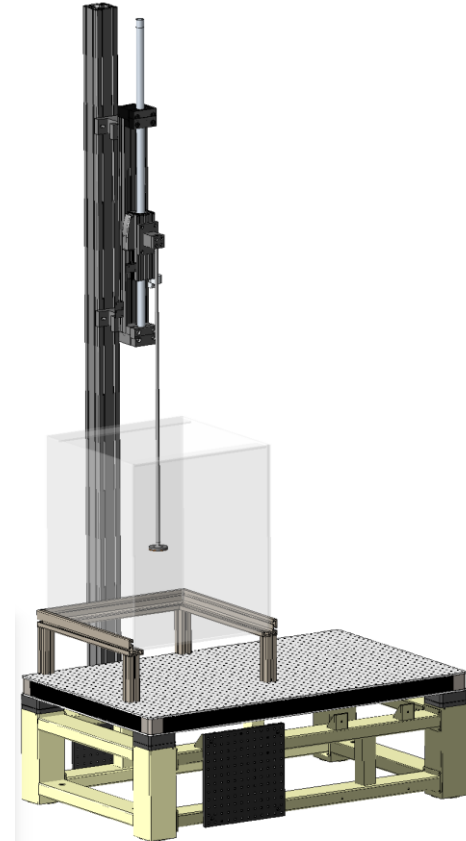
Impact loads



Lafeber et al. 2012

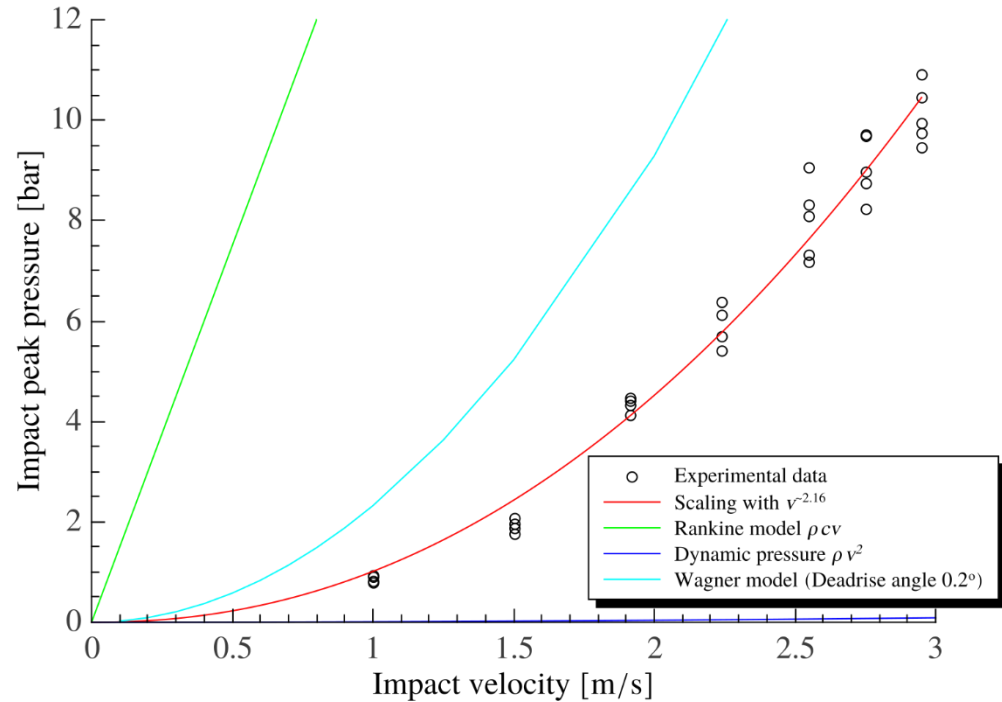
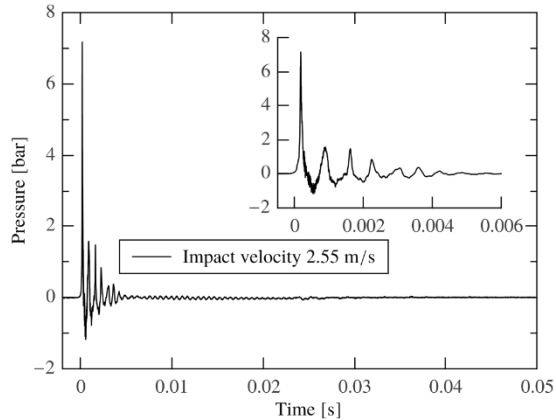
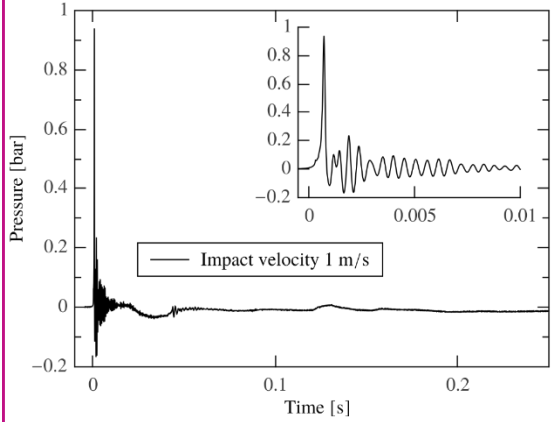
What we do...

- Study how and why the impact pressures change
- Simplify the geometry of the problem



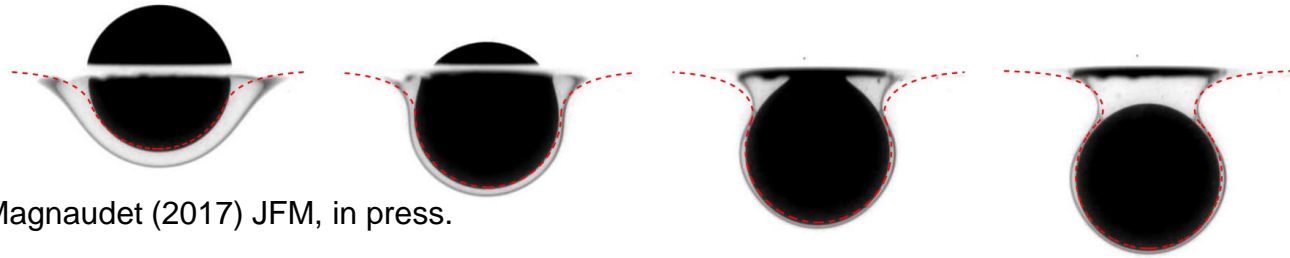
Gert-Wim Bruggert, PoF, UTwente

Water hammer pressure?

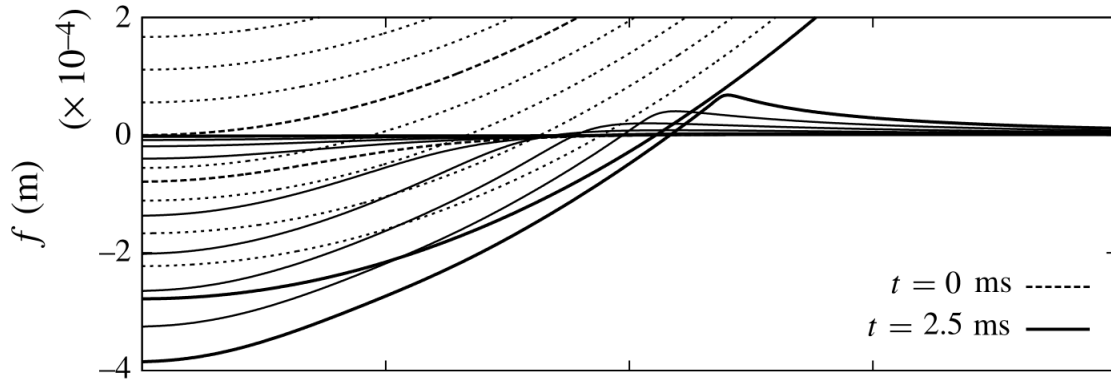


With V. Novakovic and R. v. Ginkel, MARIN

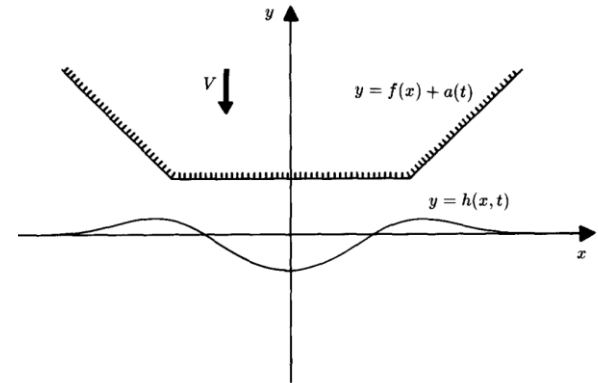
Water hammer pressure?



Pierson & Magnaudet (2017) JFM, in press.

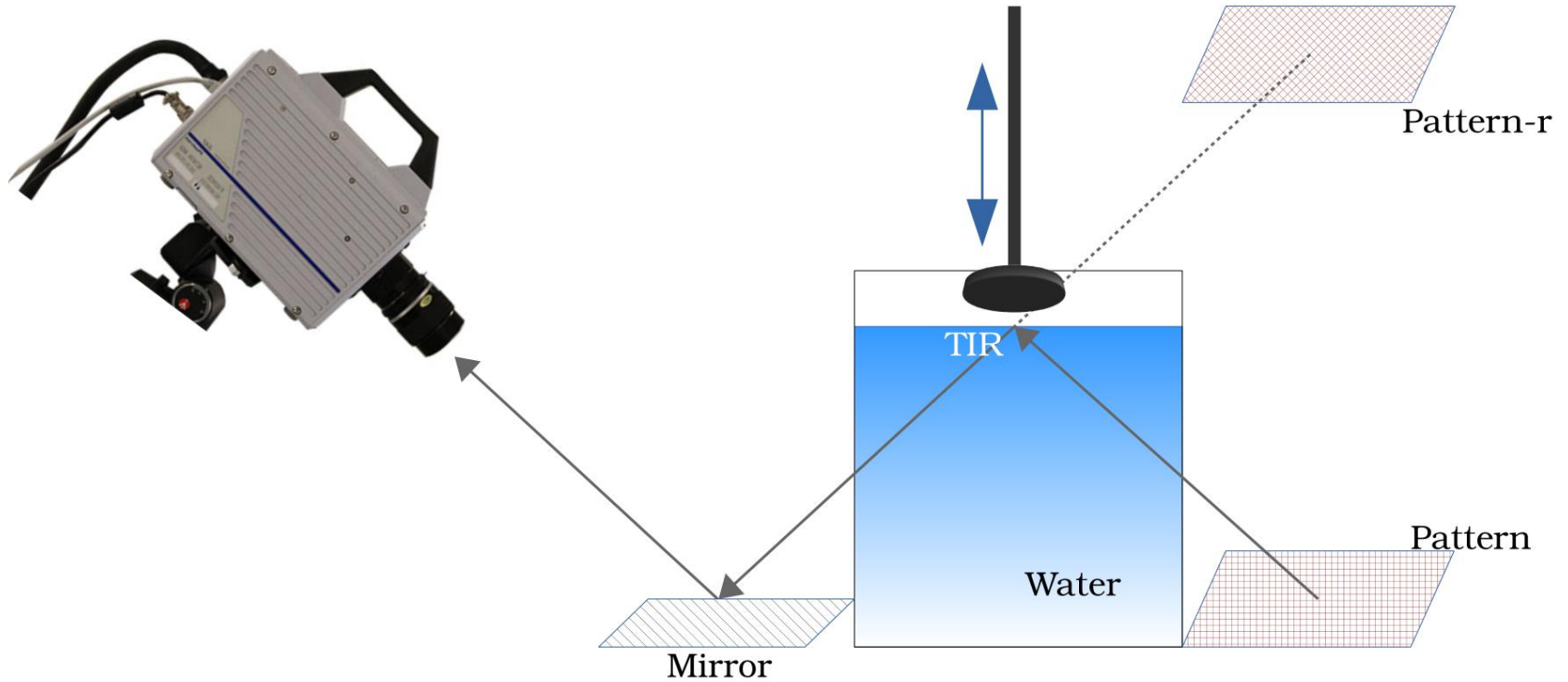


Hicks & Purvis (2012) JFM

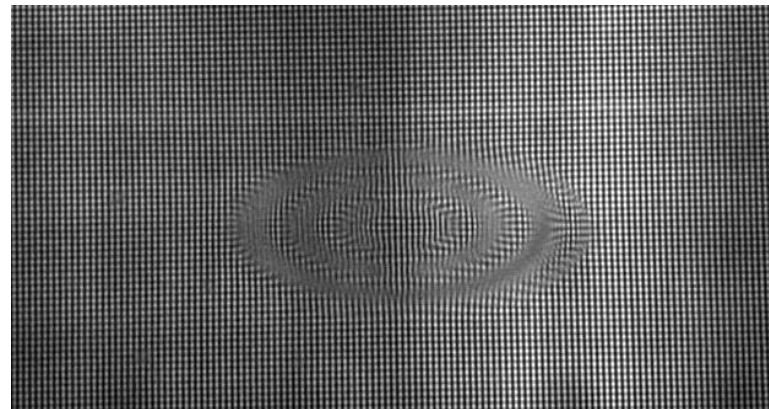
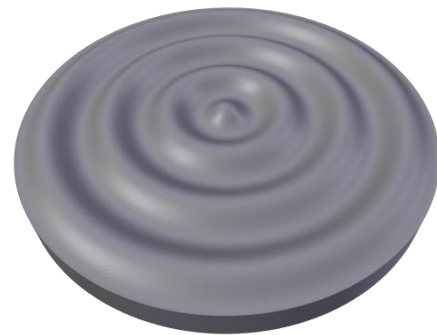
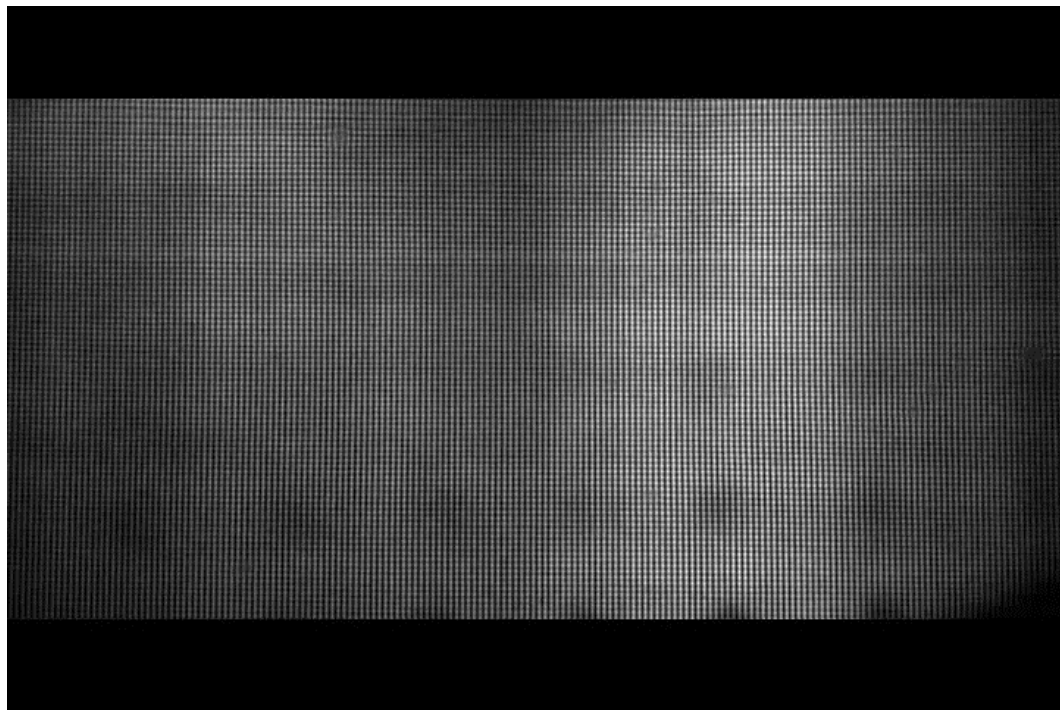


Wilson (1991) J. Engg. Math.

Setup



What I see...

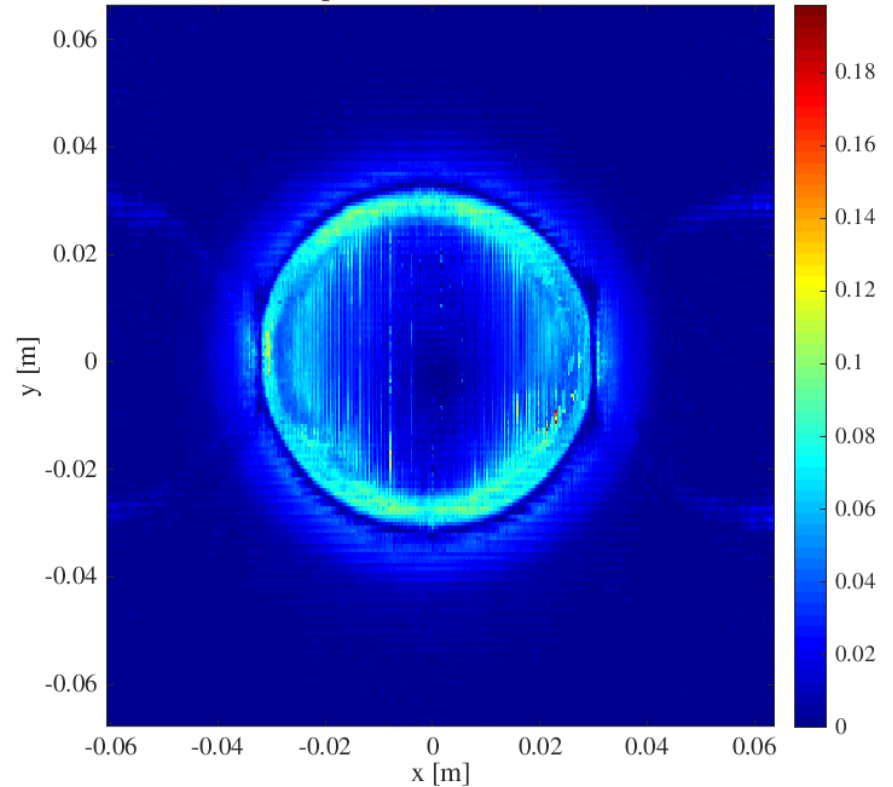


Recording at 30k fps

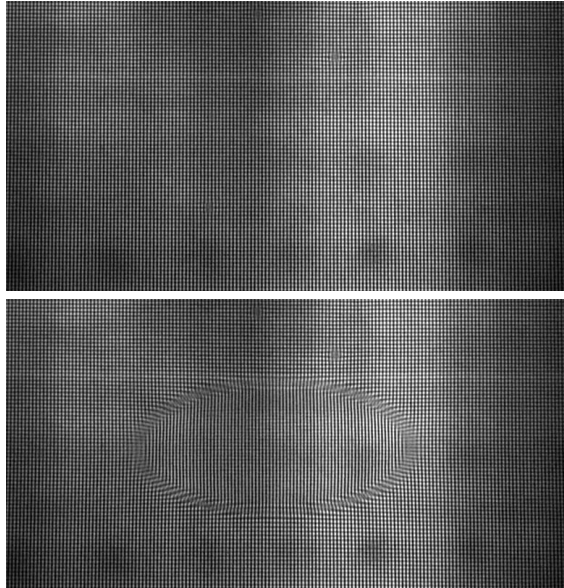
Can we learn more?

- Can get the displacement field using image correlation

OR



Other ways of getting displacement field

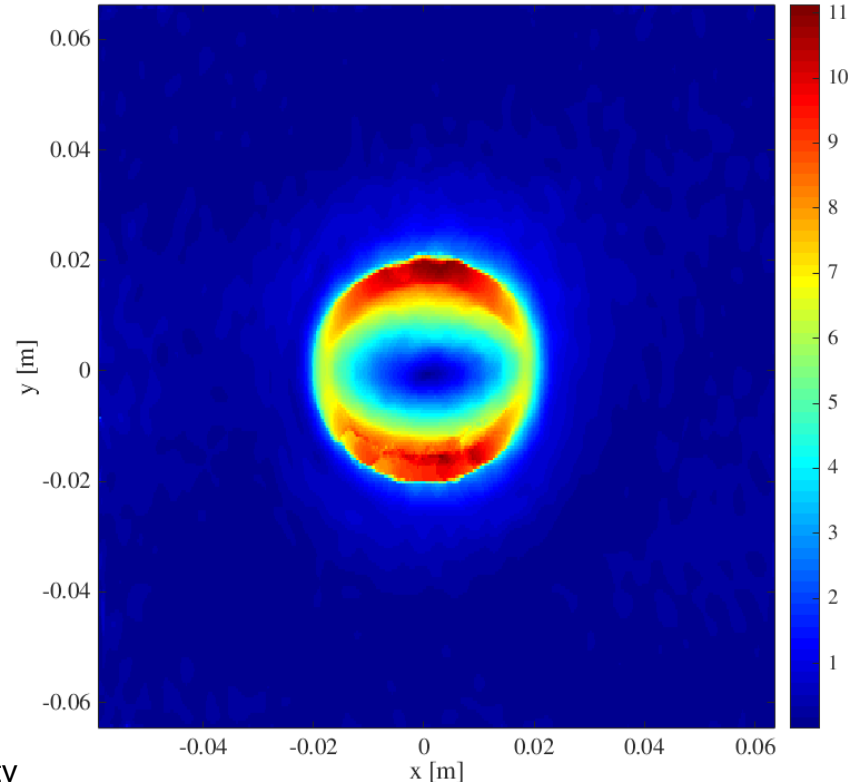


$$I_0 = e^{ik_0 x}$$

↓

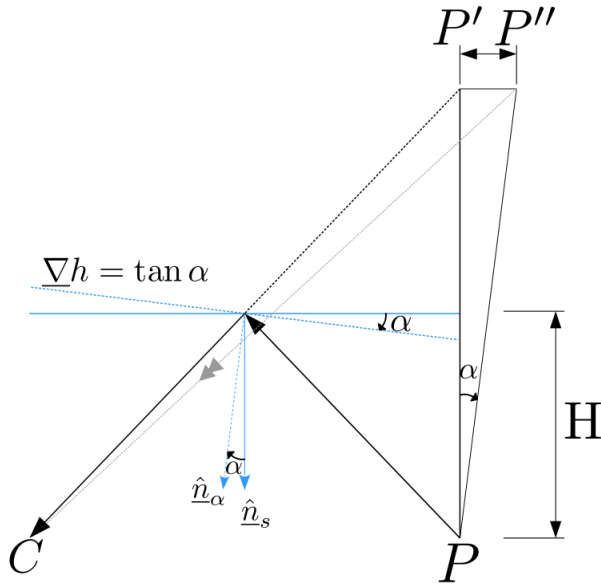
$$I = e^{ik_0(x+u)}$$

$$\frac{\text{Arg}(I \cdot I_0^*)}{ik_0} = u$$

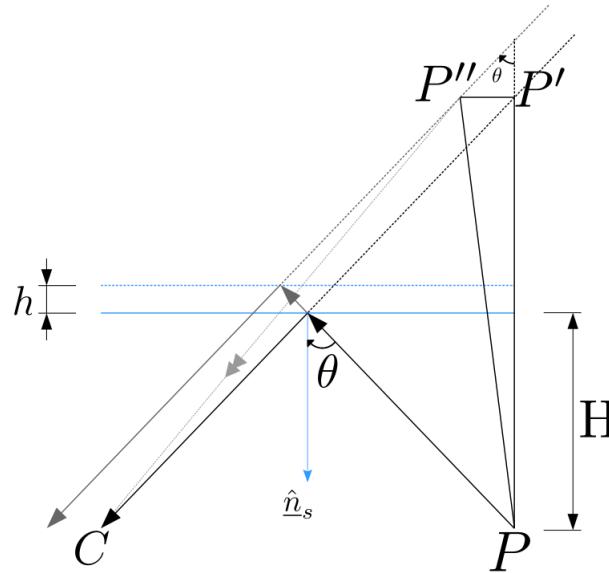


Grediac et al. (2016) Strain
 Sander Wildeman (private communication), Institut Langevin
 Cedric Devivier (private communication), Southampton university

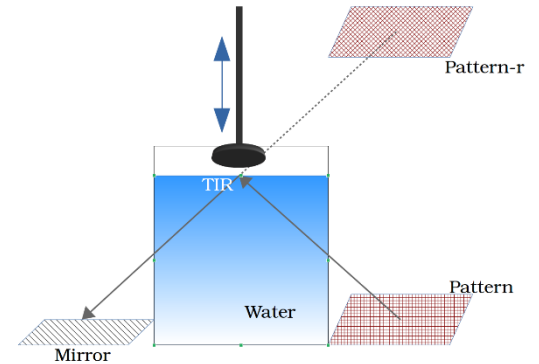
Can we learn even more?



From angular deformation,
 $P'P''_a = -2H \nabla h$

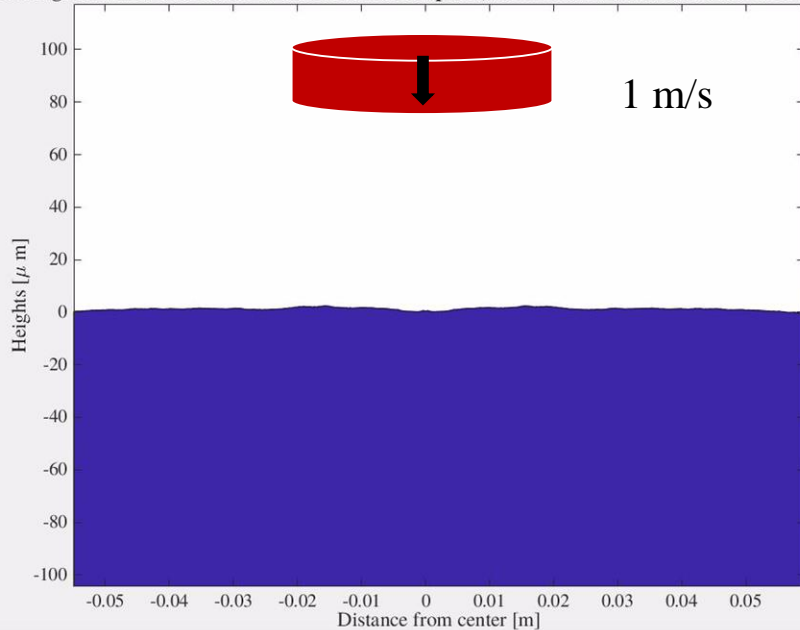


From purely vertical deformation,
 $P'P''_v = -2h \tan \theta$

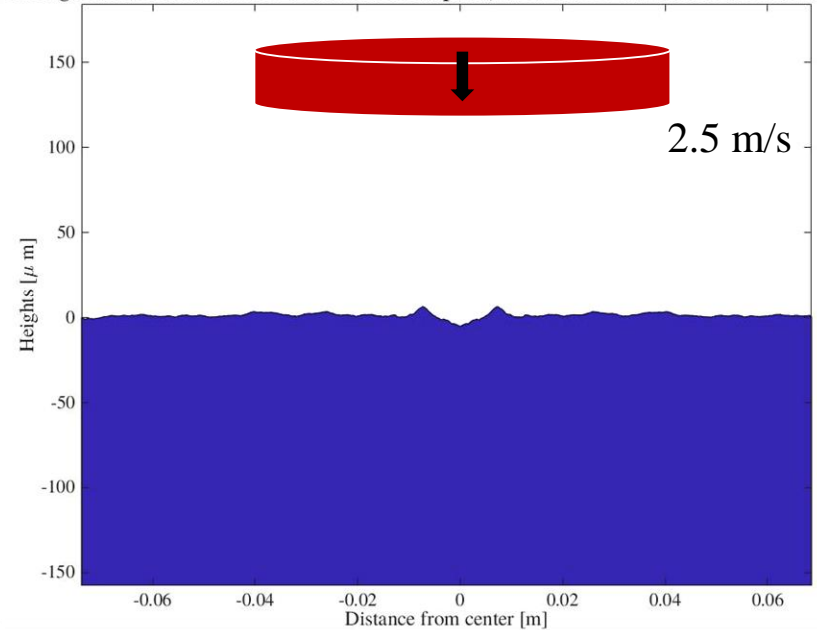


Observations – impacting flat disc

Average Radial Profile 0.015900 seconds before impact (disc is 15.9000 millimetres above free surface)



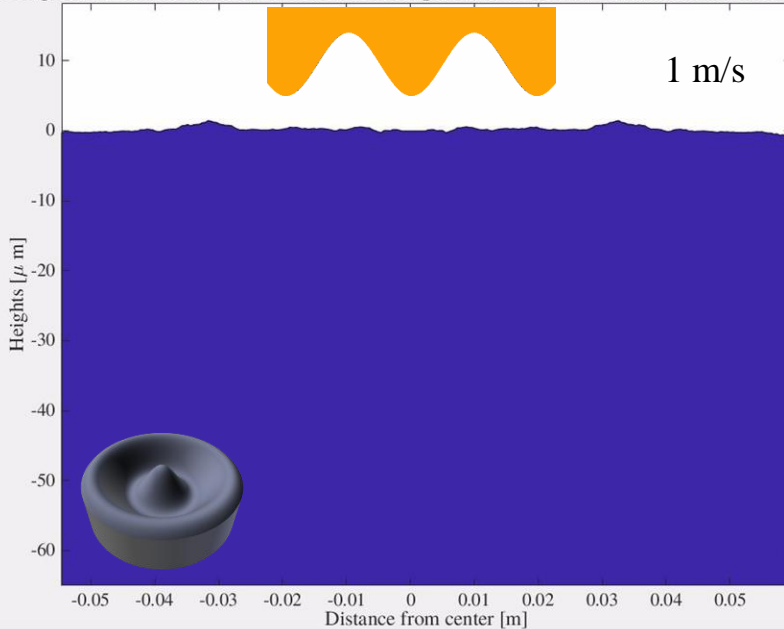
Average Radial Profile 0.013933 seconds before impact (disc is 34.8333 millimetres above free surface)



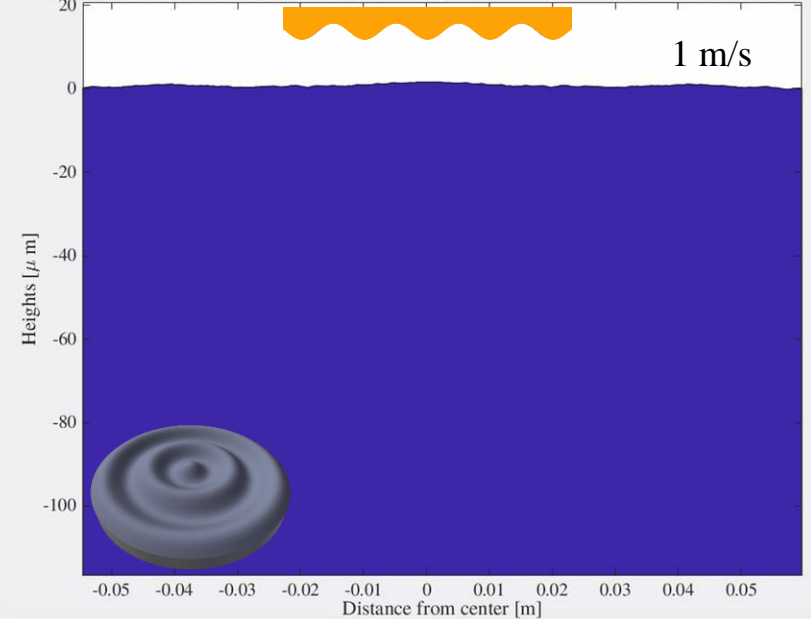
The units on x and y axes are different!

Observations – predefined impacting surfaces

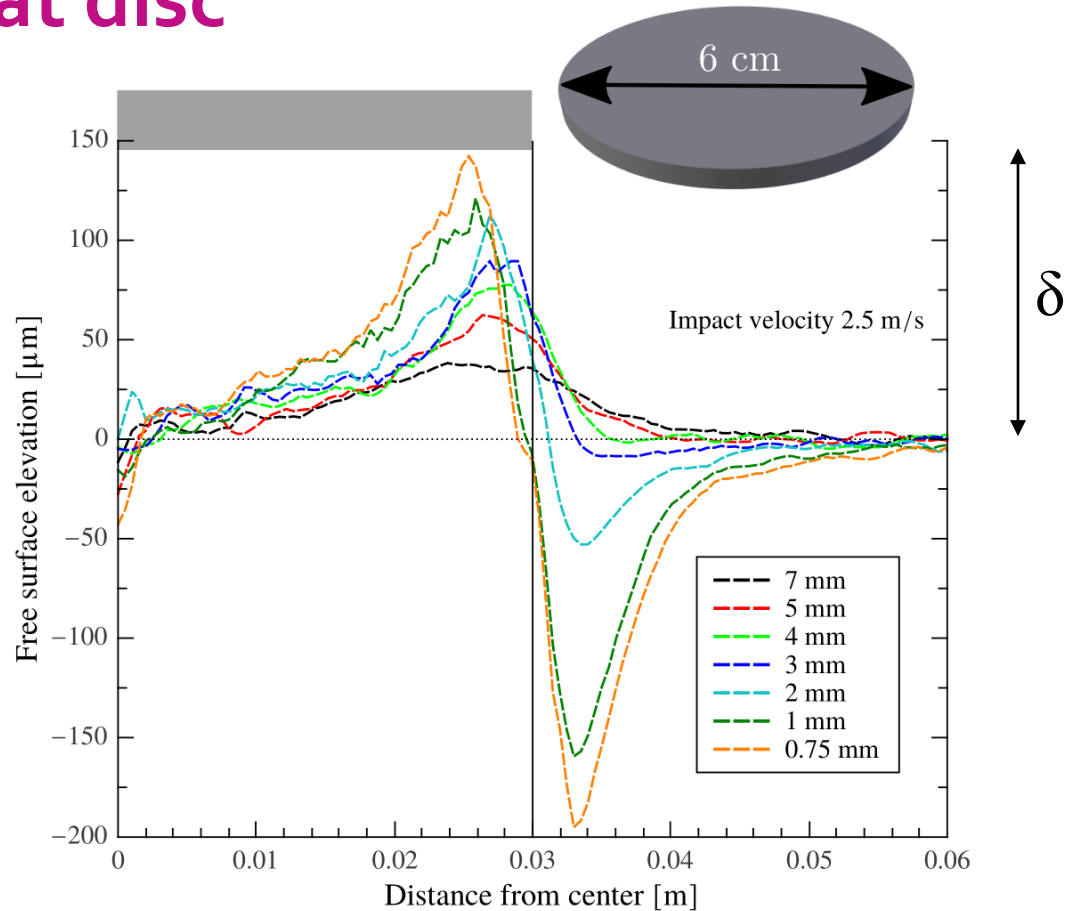
Average Radial Profile 0.019500 seconds before impact (disc is 19.5000 millimetres above free surface)



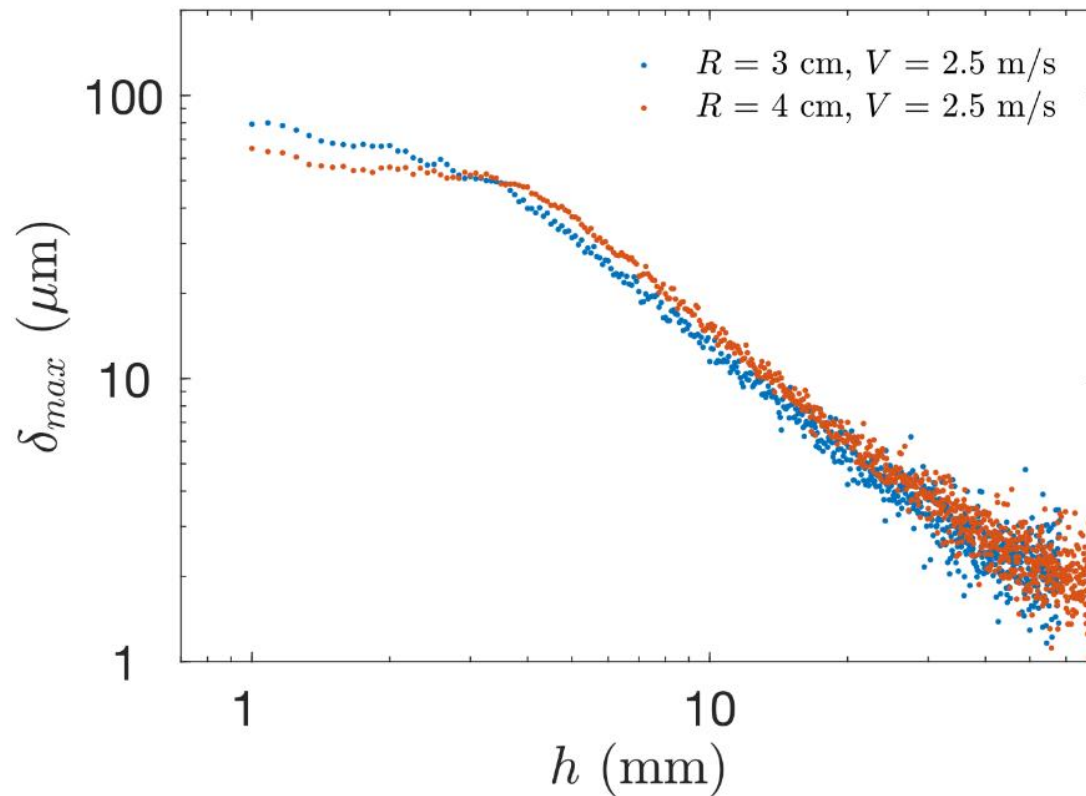
Average Radial Profile 0.015533 seconds before impact (disc is 15.5333 millimetres above free surface)



Back to flat disc



Consistent scaling behaviour?



Conclusions / outlook

- **New method to observe the free surface dynamics in impact problem (suggest a name!)**
- **Better understanding of impact problems in general**
- **Hope to draw some general conclusions from the flat disc problem**
- **Will be a much needed guide for analytical work**
- **Measure pressure distributions and correlate with what happens at the free surface**

Questions?

Email: u.jain@utwente.nl

Physics of Fluids
University of Twente
Enschede, Netherlands



Physics of Fluids
UNIVERSITY OF TWENTE.



Research School for Fluid Mechanics

MESA+
INSTITUTE FOR NANOTECHNOLOGY



MAX-PLANCK-GESELLSCHAFT