MIX2001

High Mach Number and High Initial Amplitude Effects on the Evolution of the Single-Mode Richtmyer-Meshkov Instability An Experimental Study

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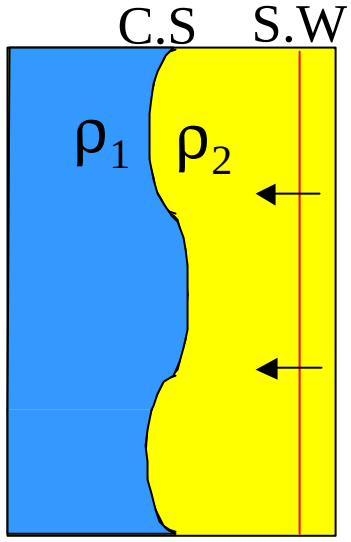
Theory: The case of a single-mode RM instability

Small initial amplitude: (Richtmyer Impulsive model)

Using:

1) Incompressible flow after the shock passes the interface.
2) Modeling the shock as:

$$g(t) = U_0 d(t)$$



Leads to a linear growth:

$$U_{bubble} = U_0 \cdot k \cdot \frac{r_1 - r_2}{r_1 + r_2} a_+$$

k wave-number

U_0-shock wave induced velocity of the contact surface

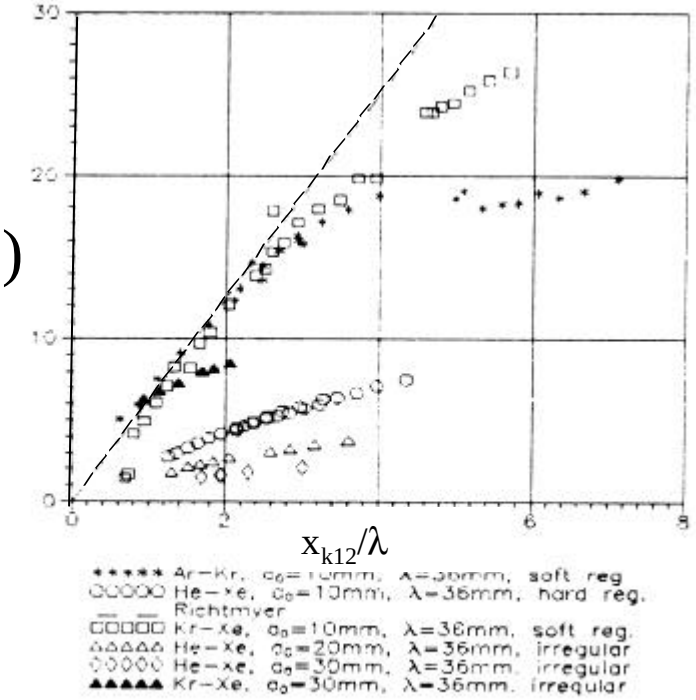
a_+- initial post shock amplitude

ρ_1, ρ_2 - densities ahead and behind the contact surface

t -time

Reduction from the impulsive model

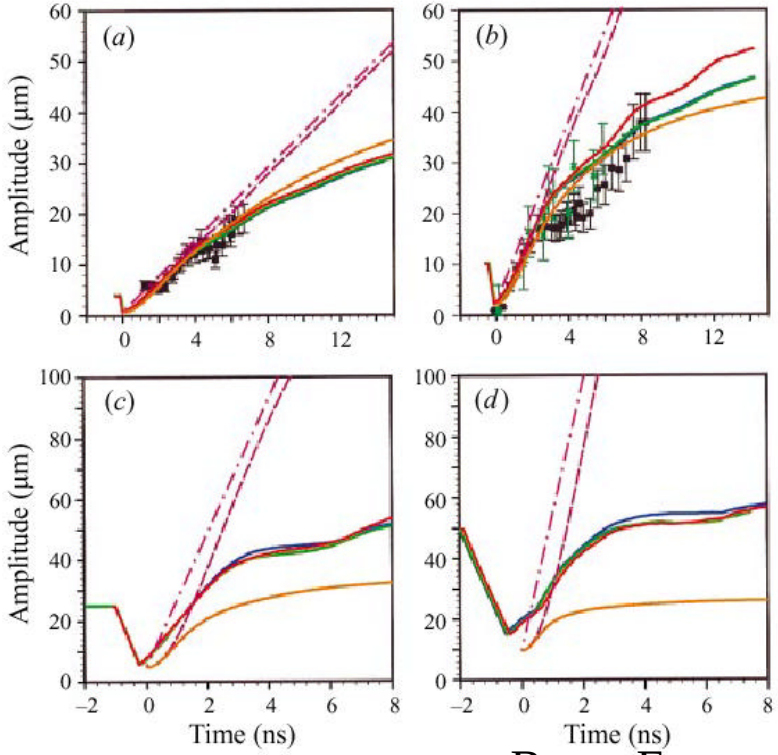
Aleshin *et al.* (1997) M=2.5 - 4.5



$$\tilde{a}(t) = (a_{k12}(x_{k12}) - a(0)_{k12})/(\dot{a}_{k12} At)$$

Dimonte *et al.* (1996) M=15.3

Holmes *et al.* (1997) a_k=0.63



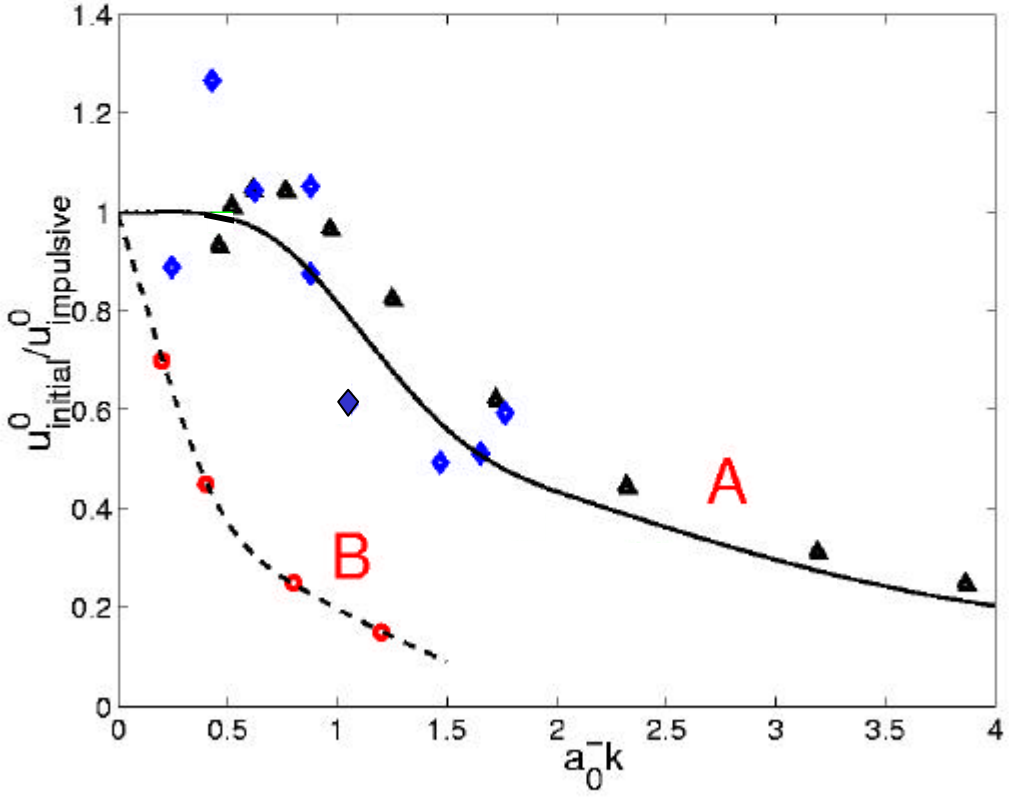
Be → Foam

At high Mach numbers:

$$U = \min(U_{richtmyer}, U_{Transmitted} - U_{Interface})$$

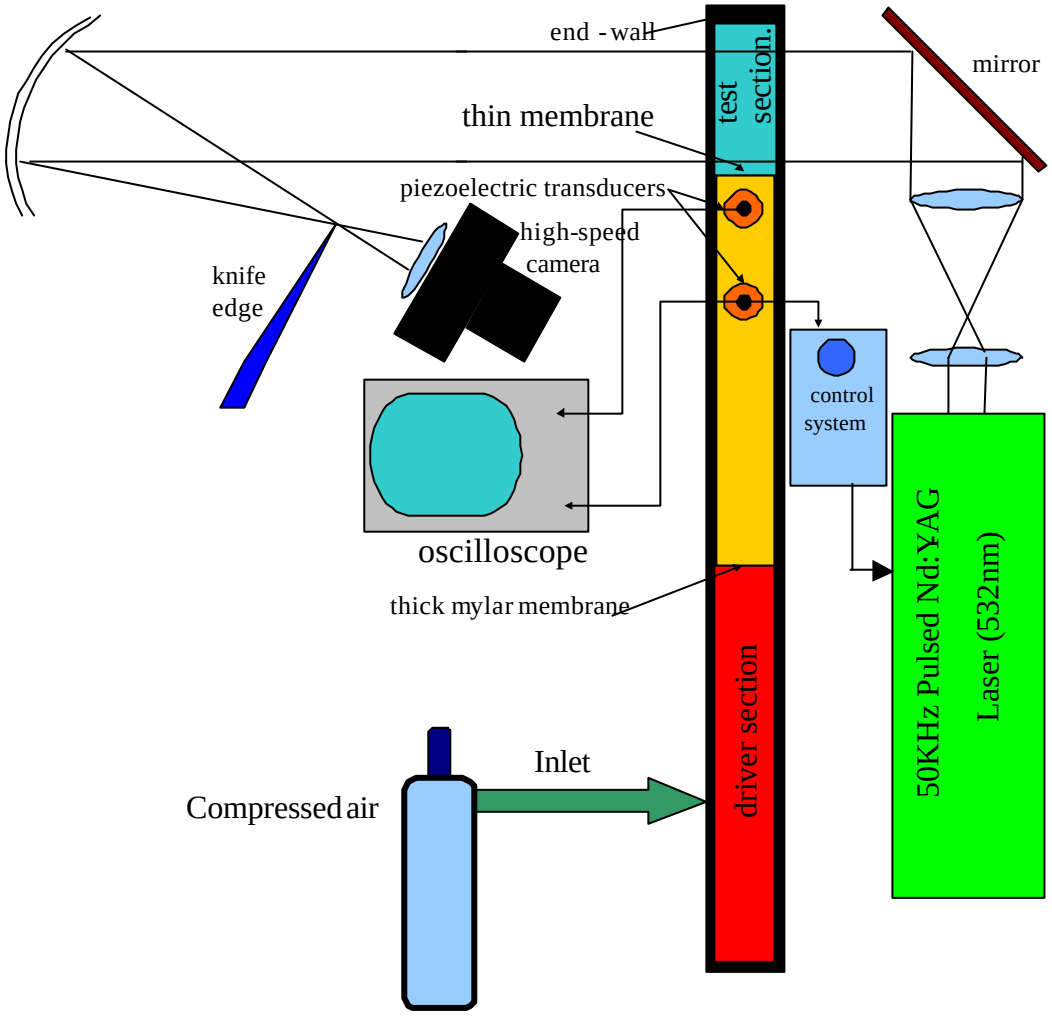
The reduction is a high Mach number effect

Experimental results: reduction from the impulsive model

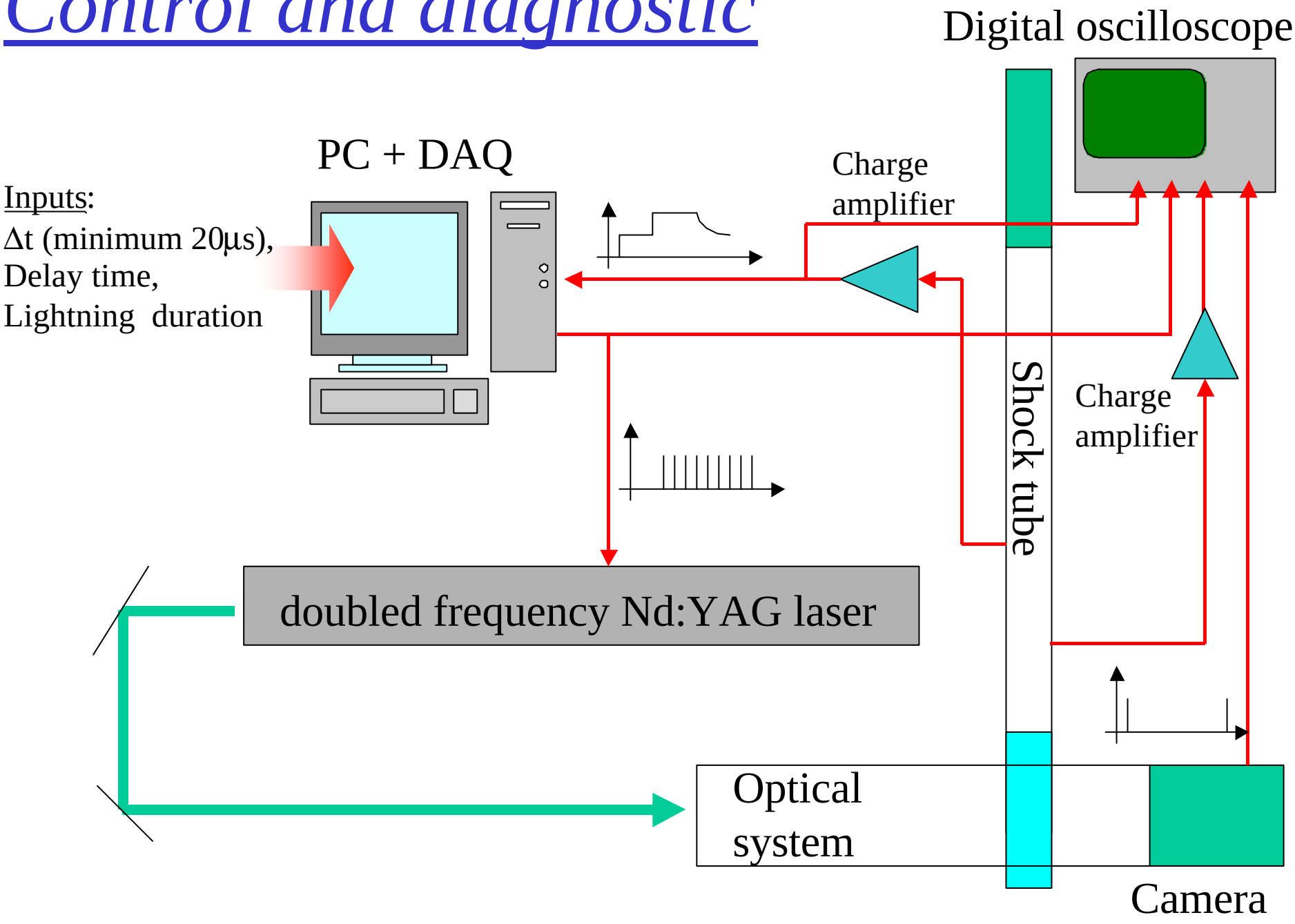


- Dimonte Be → Foam (M=15.3)
- Aleshin Ar → Xe (M=2.5)
- Aleshin He → Xe (M=2.5)

Experimental Apparatus



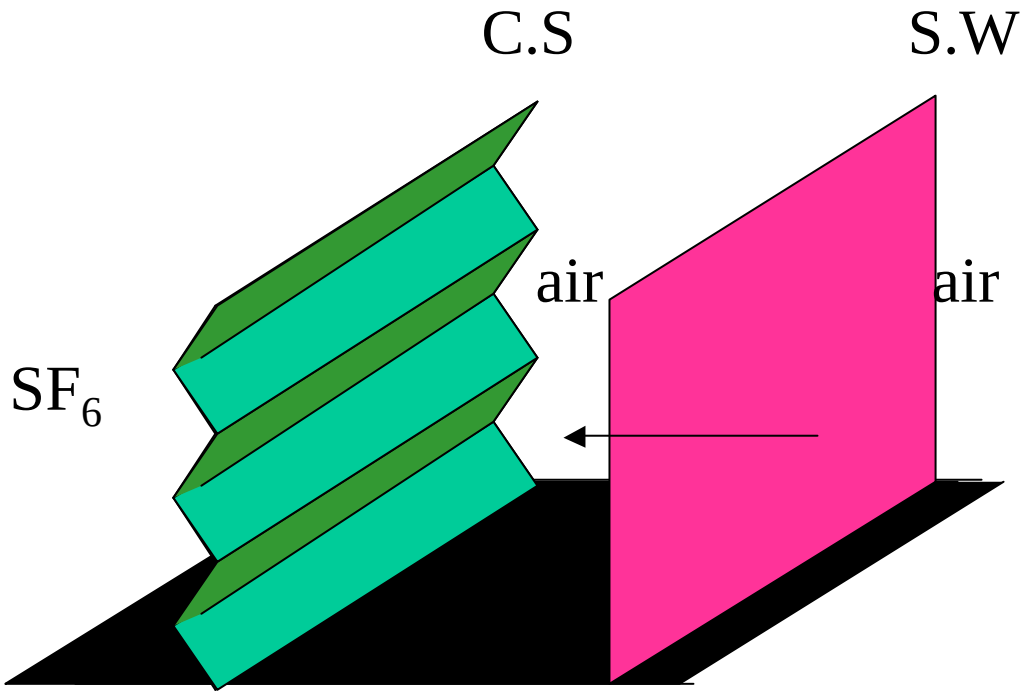
Control and diagnostic



Experimental apparatus The membrane

Mach number M=1.2

λ	a_	a_k
80mm	40mm	3.14
26mm	10mm	2.45
40mm	12mm	1.9
80mm	20mm	1.57
40mm	7mm	1.1
40mm	3mm	0.5

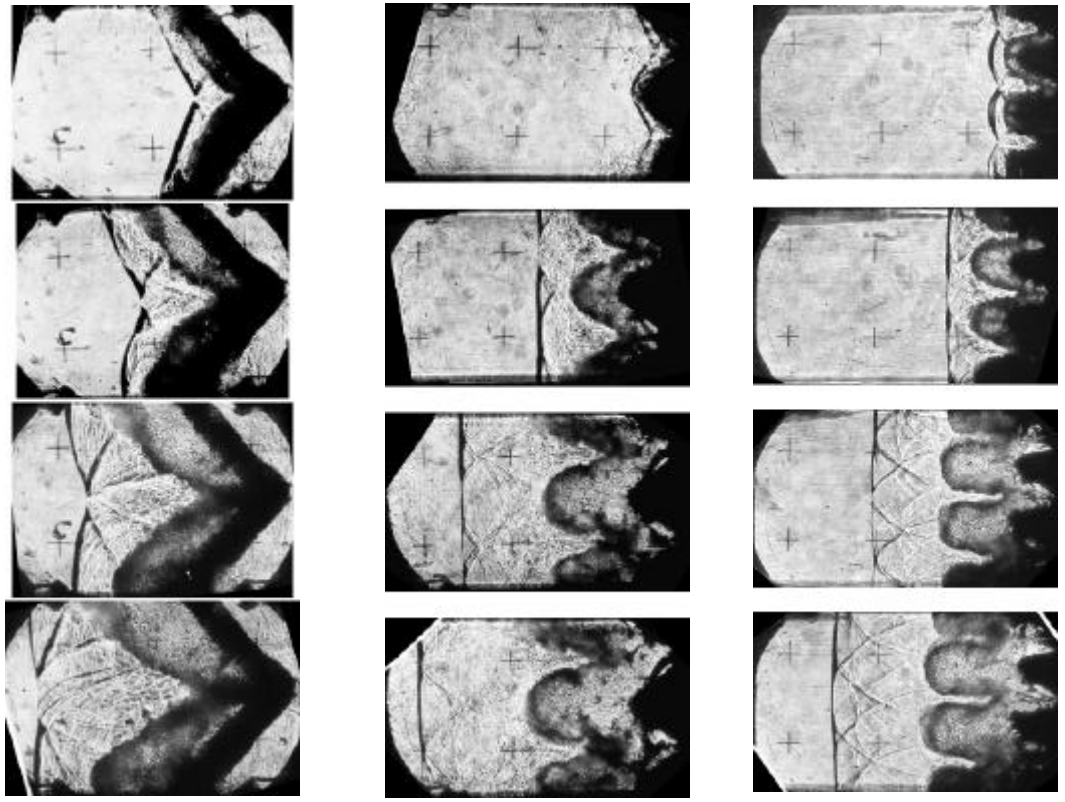


Experimental results (M=1.2)

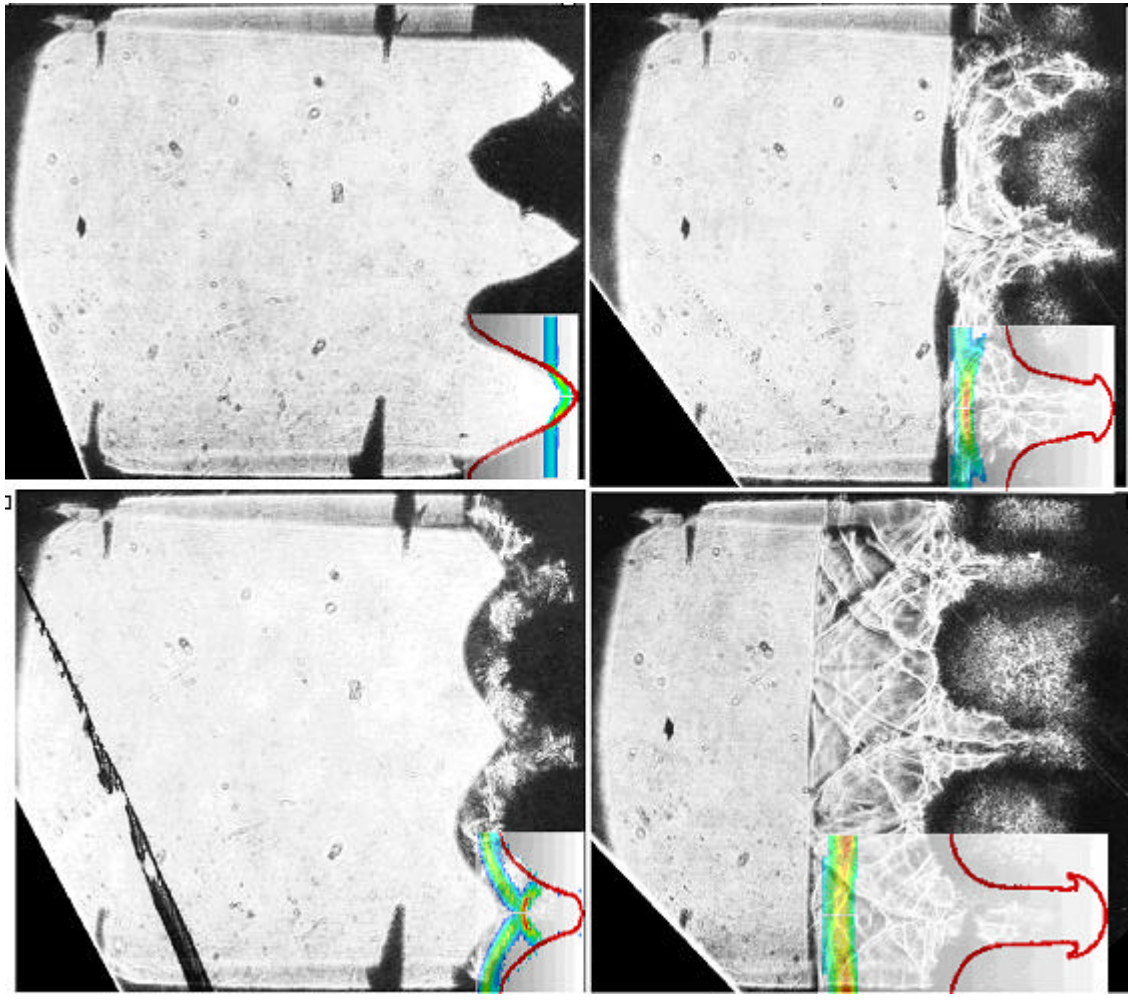
λ=80mm
a=20mm

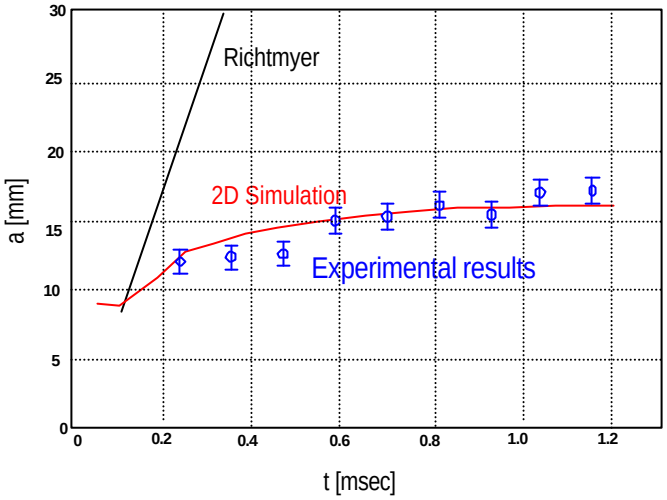
λ=40mm
a=12mm

λ=26mm
a=10mm



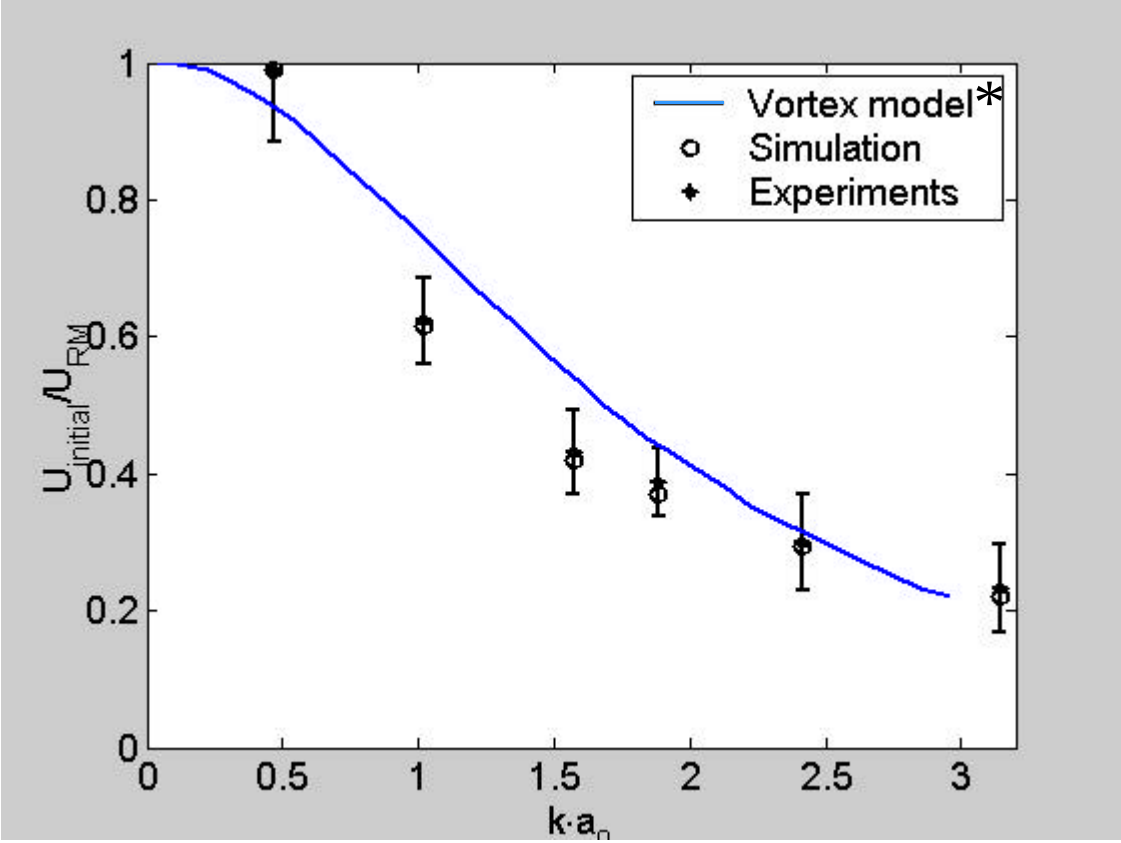
Numerical simulation





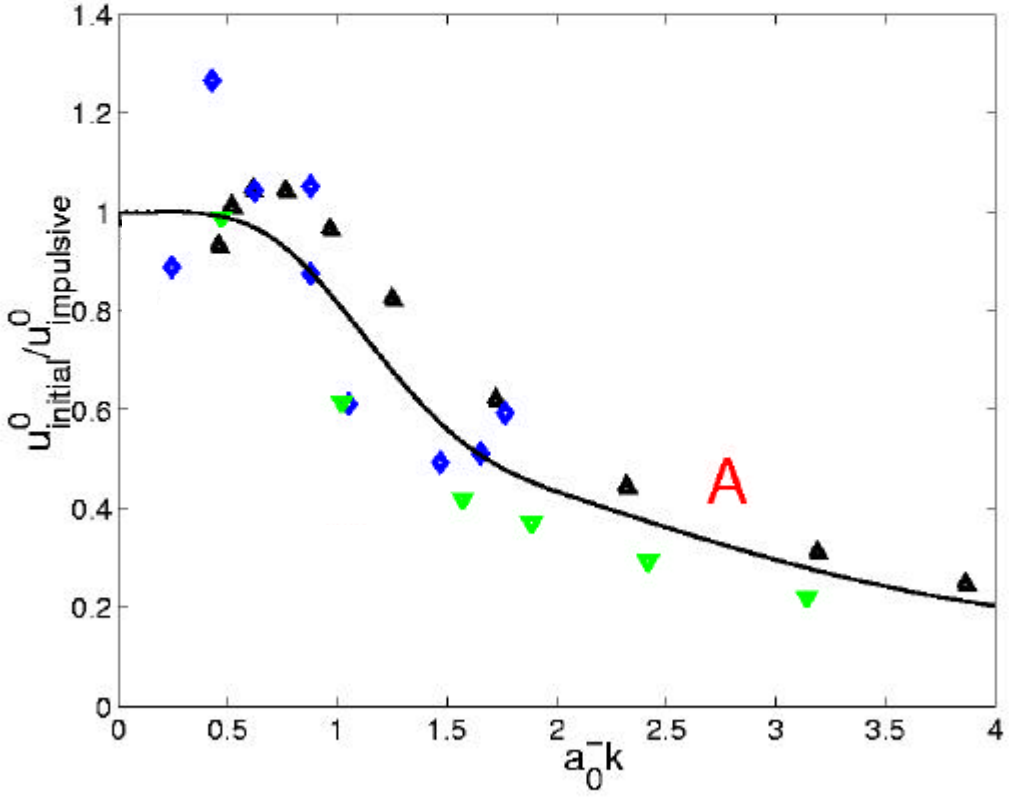
The initial velocity was found from the simulation

Reduction from the impulsive model: Results of experiment, model and simulation



* See Rikanati Thursday T23.

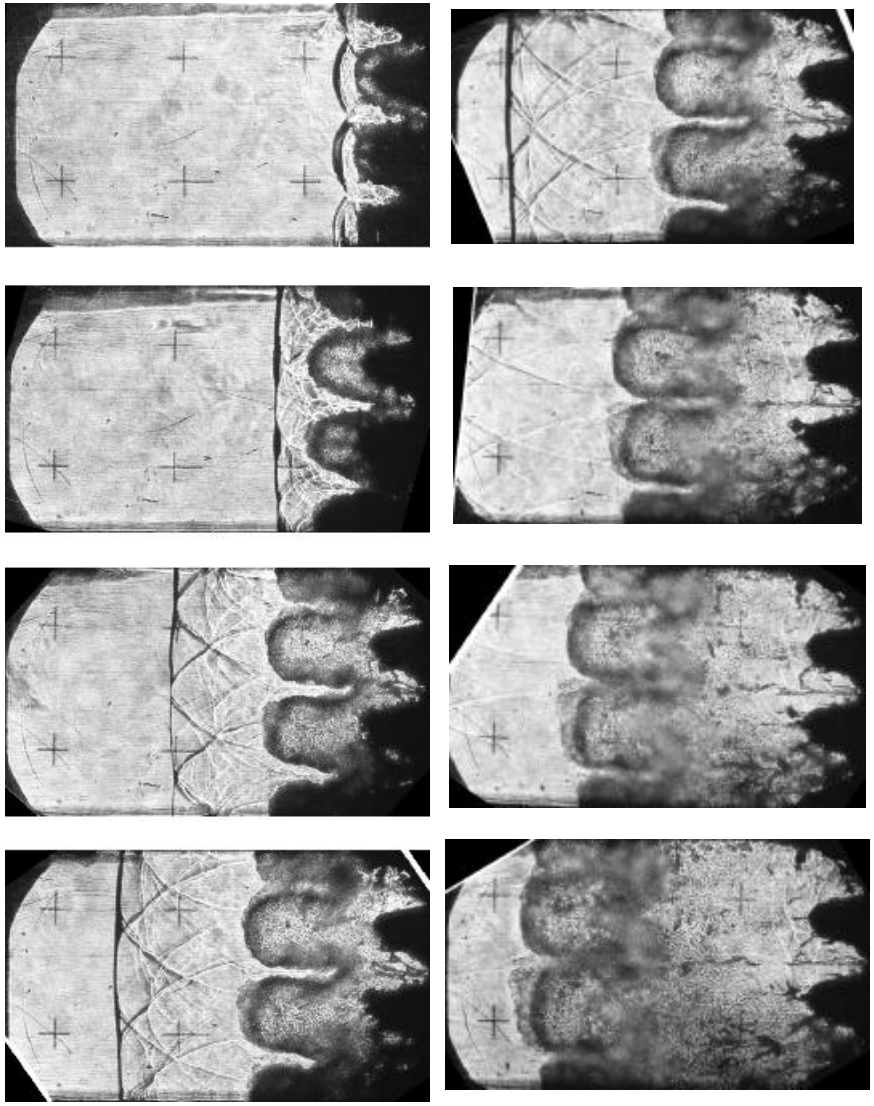
Experimental results: reduction from the impulsive model

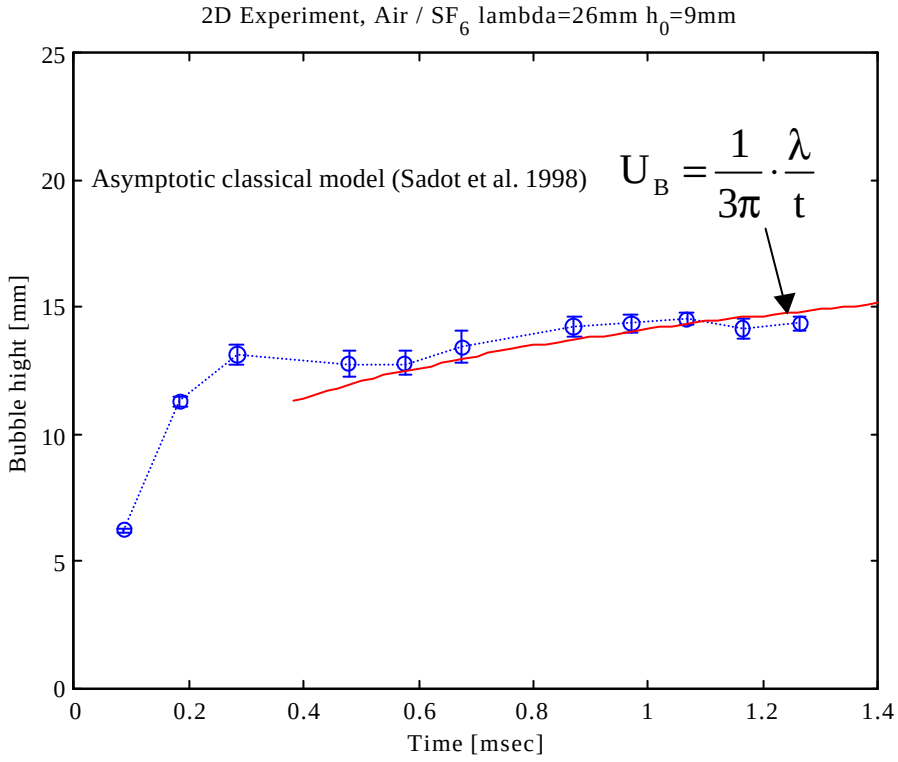


- Dimonte Be → Foam (M=15.3)
- Aleshin Ar → Xe (M=2.5)
- Sadot Air → SF_6 (M=1.2)

High initial amplitude effect

Bubble late time evolution in the large amplitude experiment

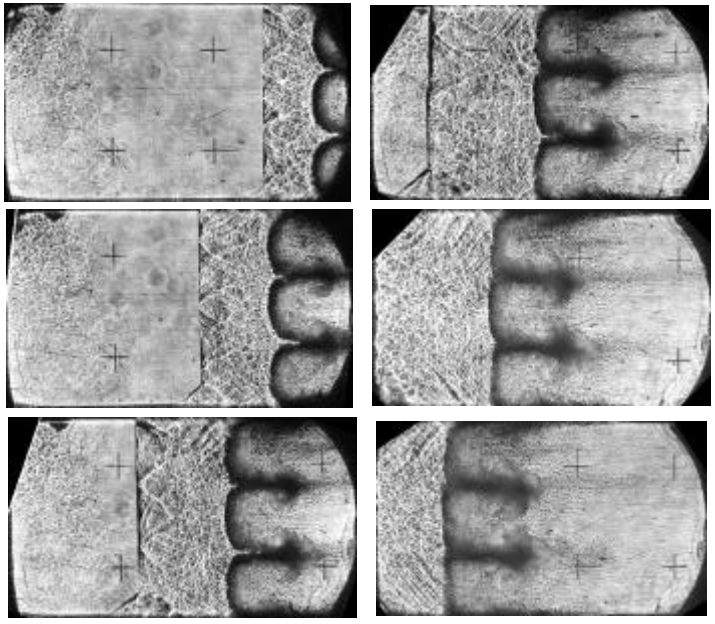


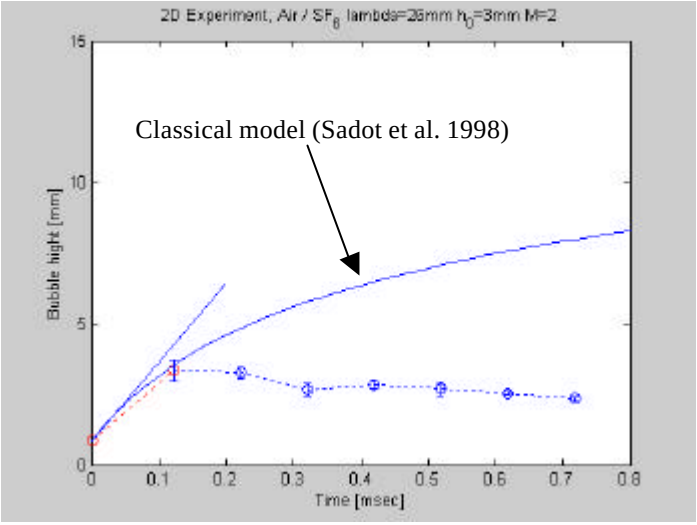


Late time reduction from the classical models due to high Mach number effects

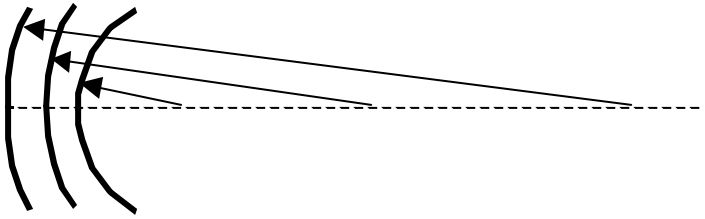
a_0=3mm, M =2

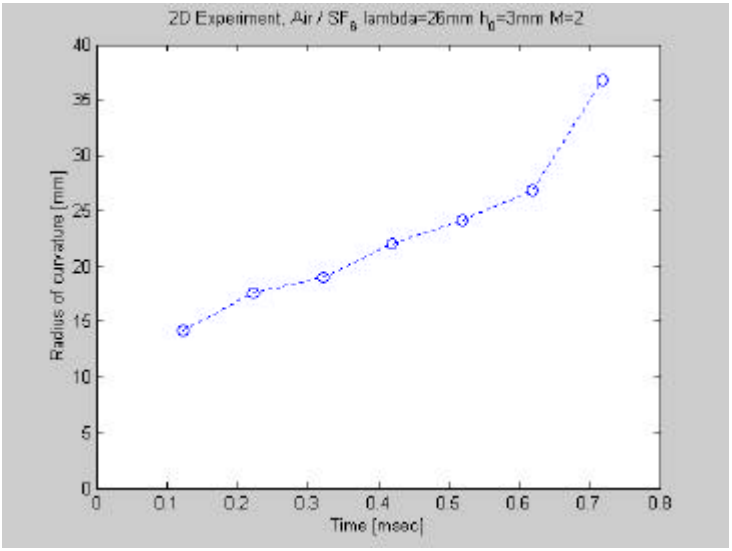
air to SF_6 ($\gamma_{SF_6} = 1.09$)



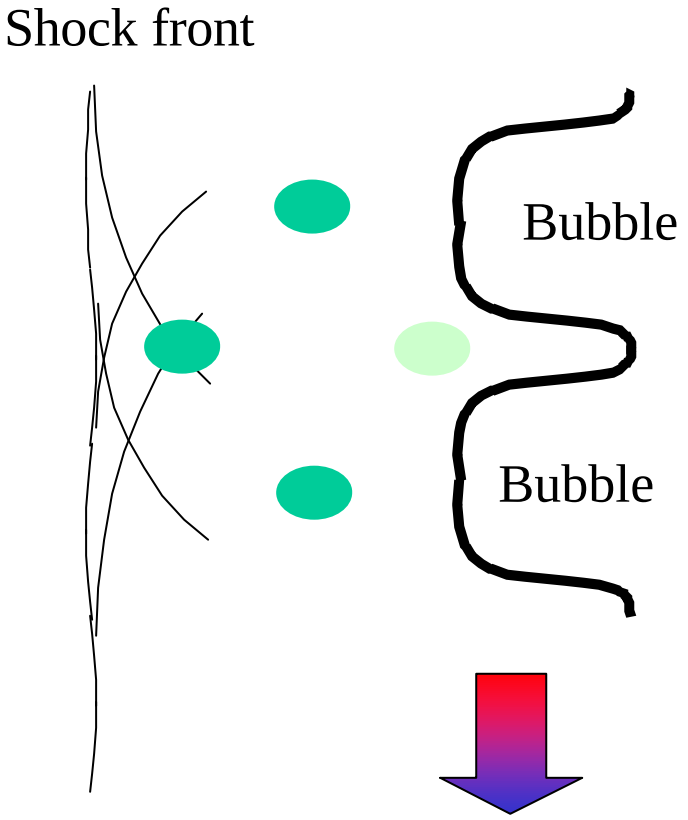


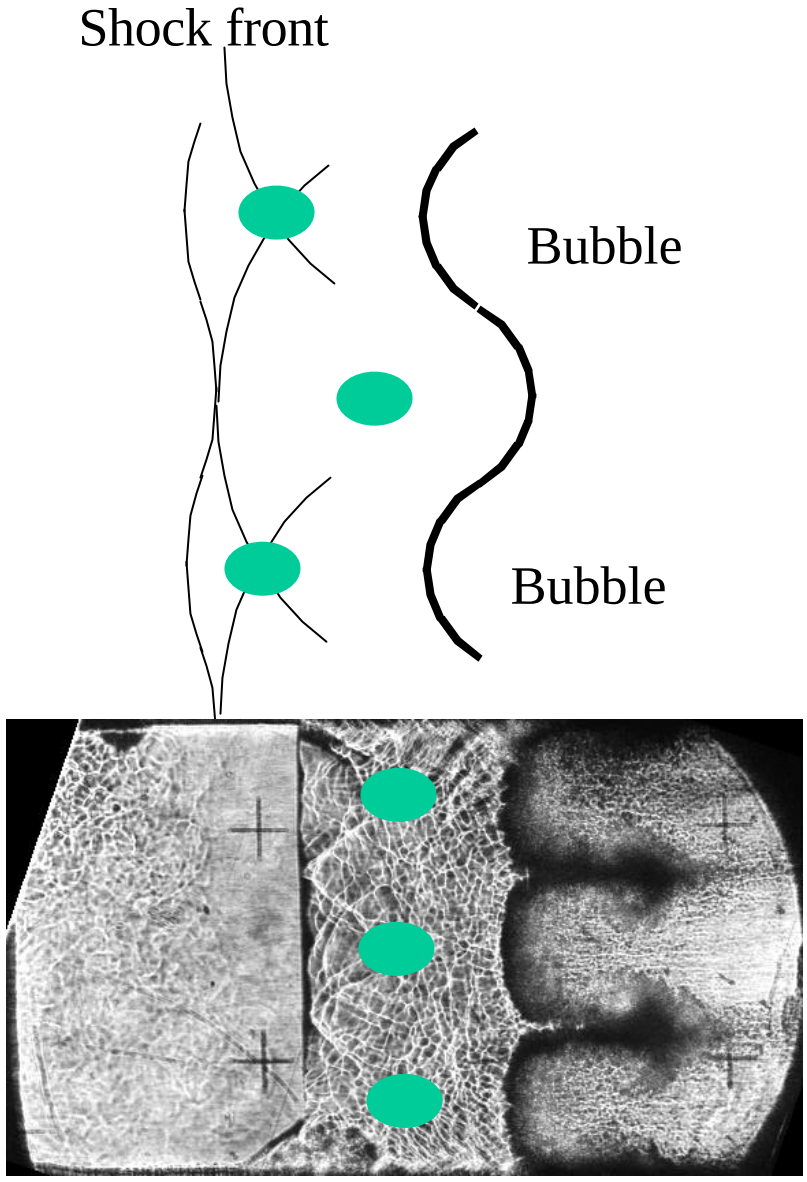
The radius of curvature of the bubble:





At late time the shock reverberation reduces the bubble growth rate





The growth velocity is reduced
The radius of curvature is increased

Summary

Effects of high initial amplitudes were quantified experimentally for the early linear stages of the flow.

The reduction from the Richtmyer initial velocity occur even at low Mach number (M=1.2).

For the late nonlinear stages of the flow:

- The initial amplitudes effect was forgotten and the bubble evolves as in the classical case (depends only on the wave length).
- New effect was observed for high Mach numbers which decreases the bubble asymptotic velocity.