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A Novel Launcher for Cavitating Weapons

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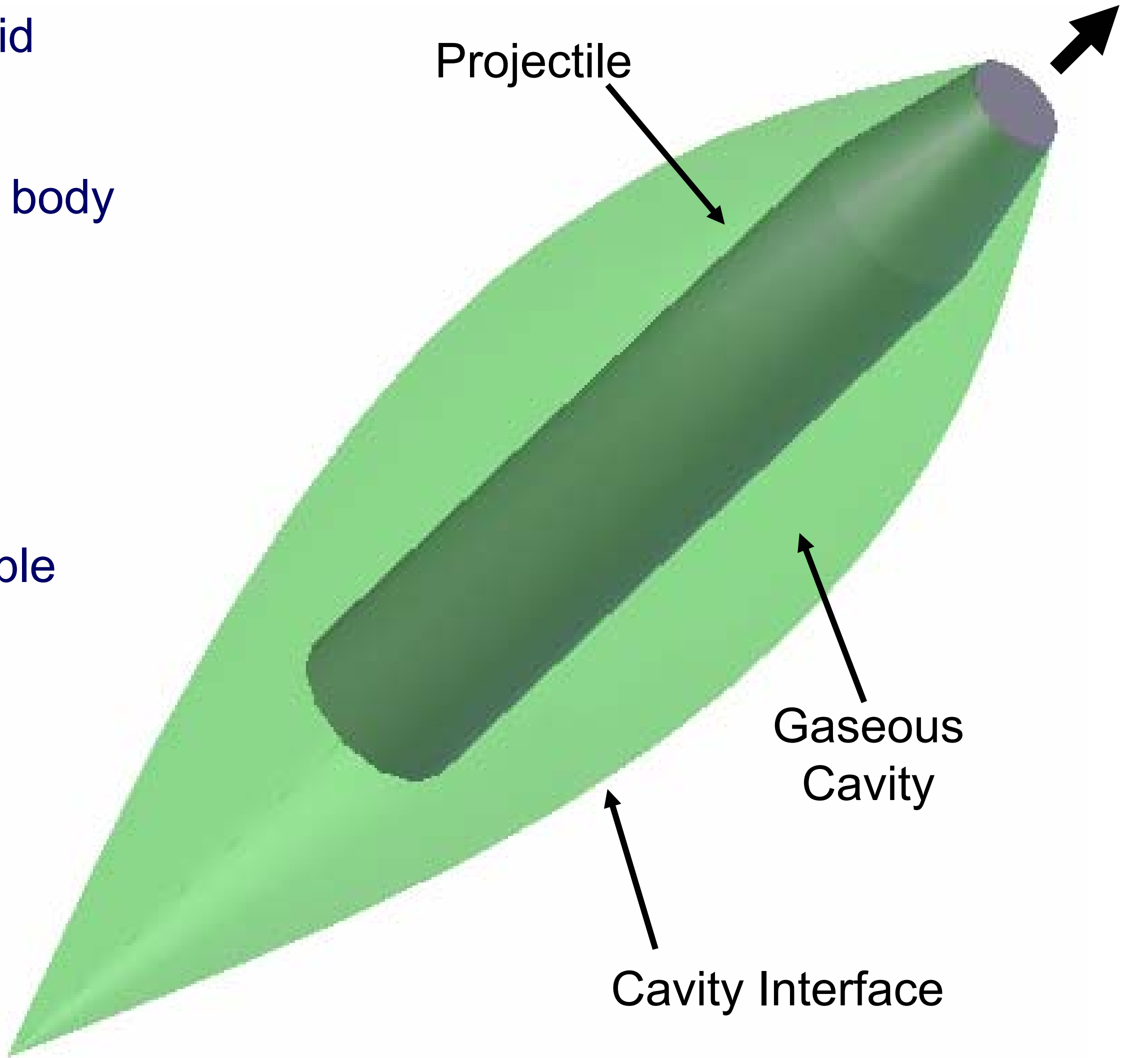
Supercavitation

- Stresses exerted on ambient fluid drops below a critical value
- A gaseous cavity envelopes the body and moves with it
- Viscous interaction between projectile surface and water is alleviated (i.e. drag reduction)
- Large underwater speeds possible

$$\sigma = \frac{p_h - p_c}{\frac{1}{2}\rho U^2}$$



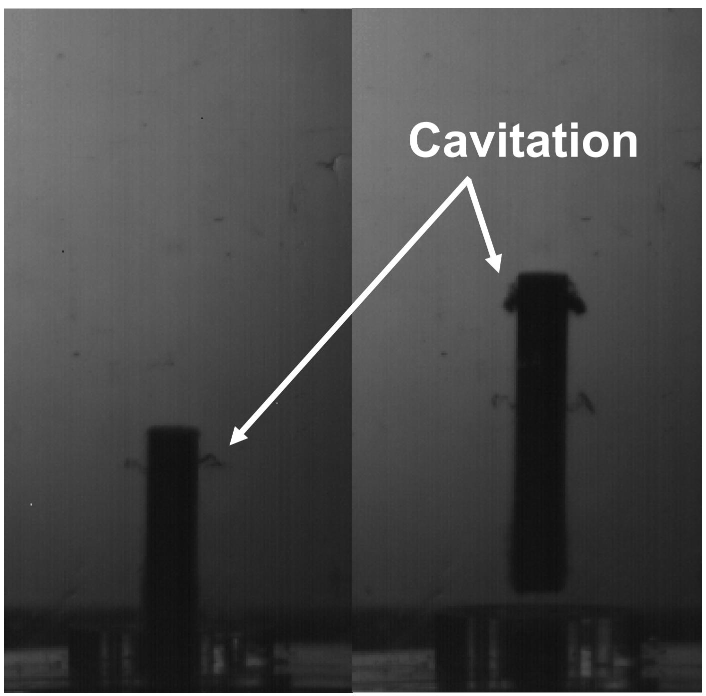
Supercavitation Inception

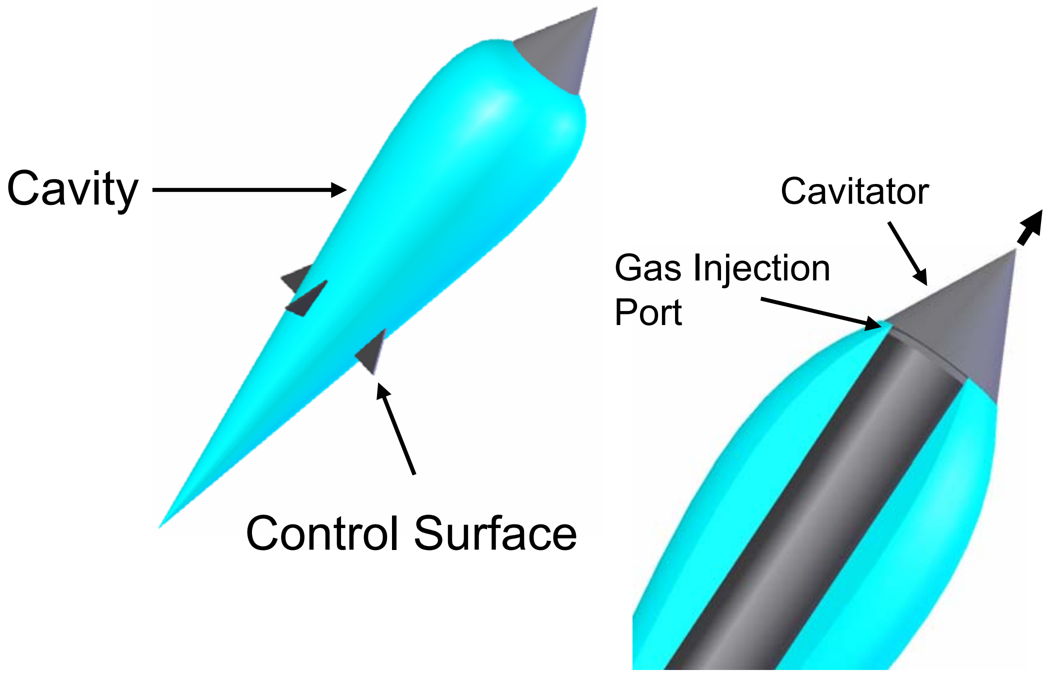
- **Pure Hydrodynamic Cavitation** – Naturally occurring nuclei (small gas bubbles) explosively grow due to fluctuating pressure field in the separated flow region.

Extremely High Speeds Required For Pure Hydrodynamic Supercavitation

- **Artificial (Ventilated) Cavitation** – Pressurized gas is injected behind the cavitator. Supercavitation at lower speeds is possible.

Requires a Pressurized Source of Gas to be Carried On-Board or Plumbing to Re-Direct Exhaust Gases





Inception via Gas Entrainment

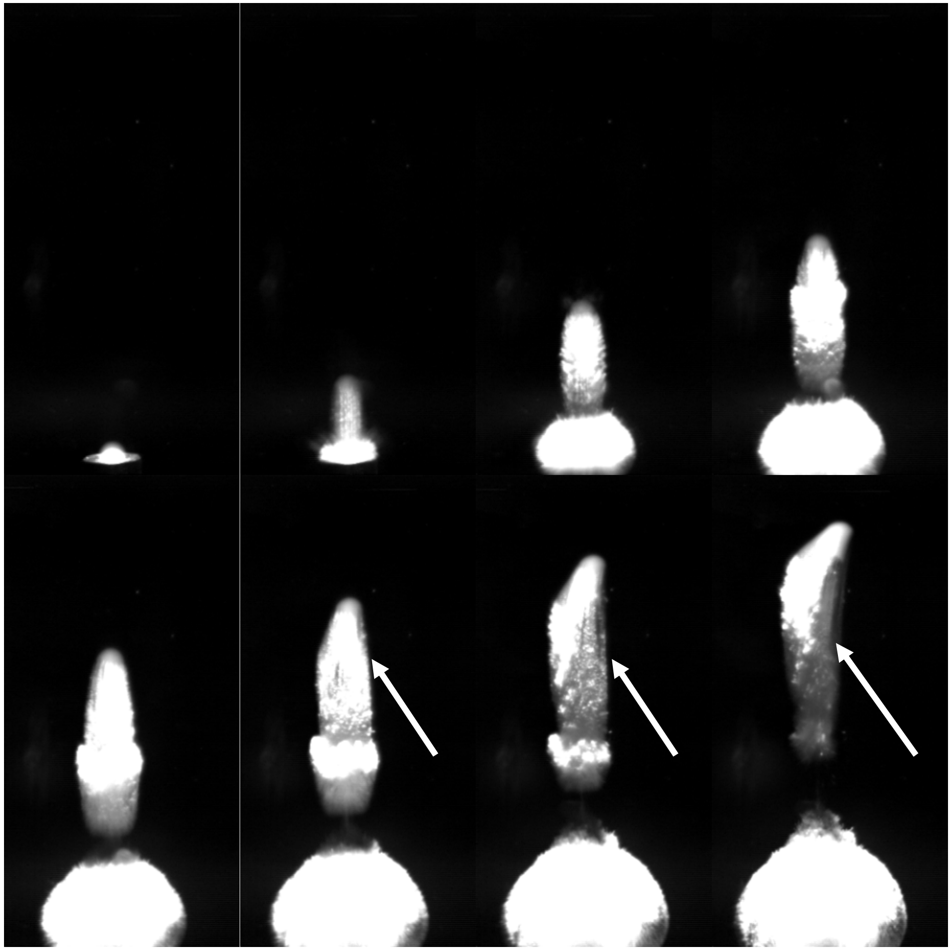
How Can We Achieve the Best of Both Worlds?

- Pressurized gas is injected during launch

- The pressurized gas fills the separated flow region, resulting in a fully developed cavity

- Velocity required to initiate supercavitation in drastically reduced

Allows a state of supercavitation to be prematurely attained until pure hydrodynamic supercavitation can ensue



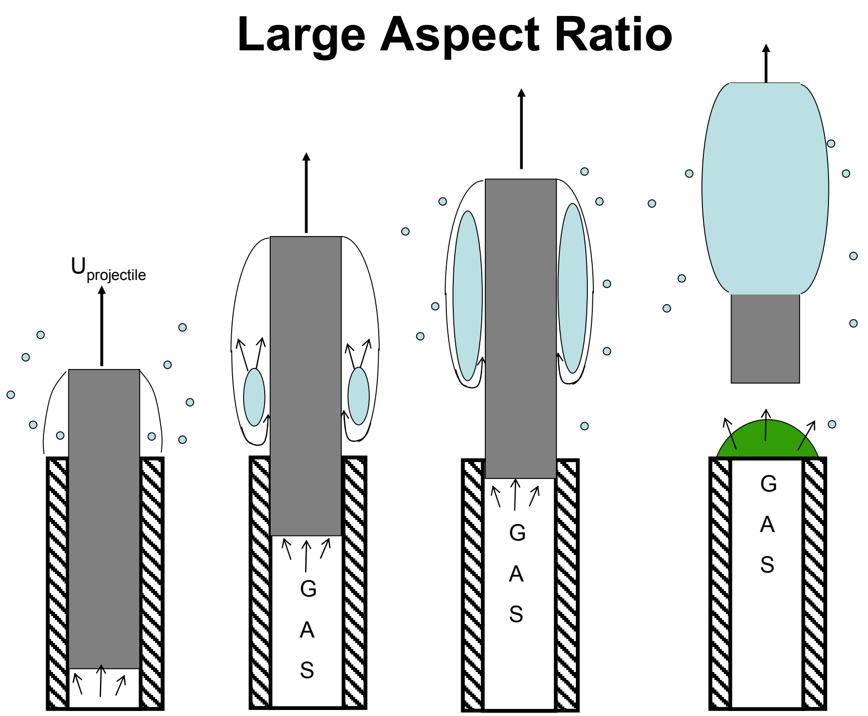
U_0 = 45 m/s

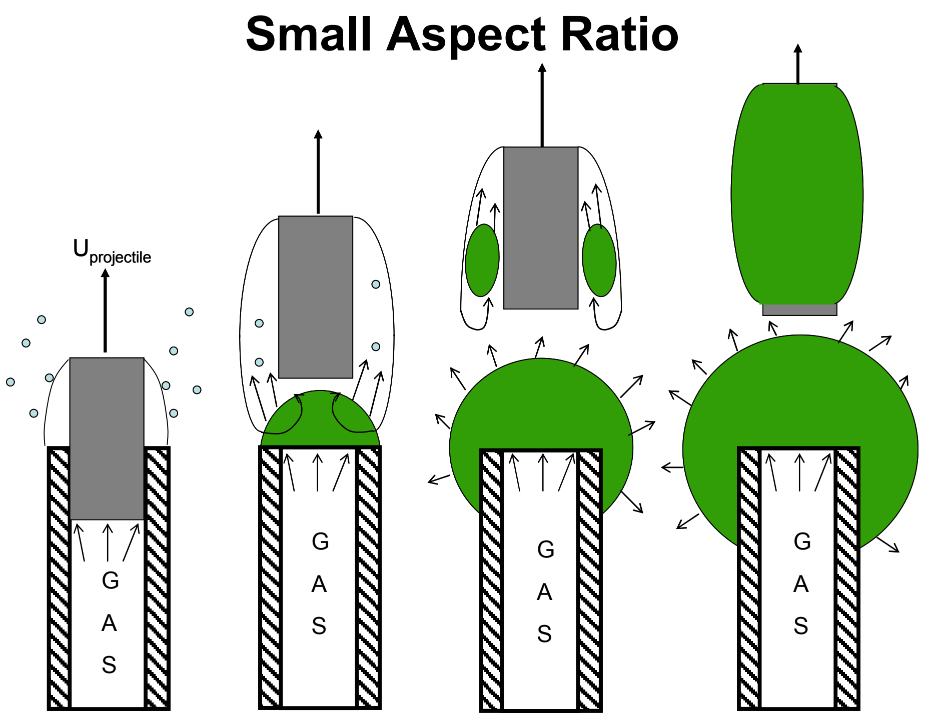
σ = 0.1

(not accounting for injected gas)

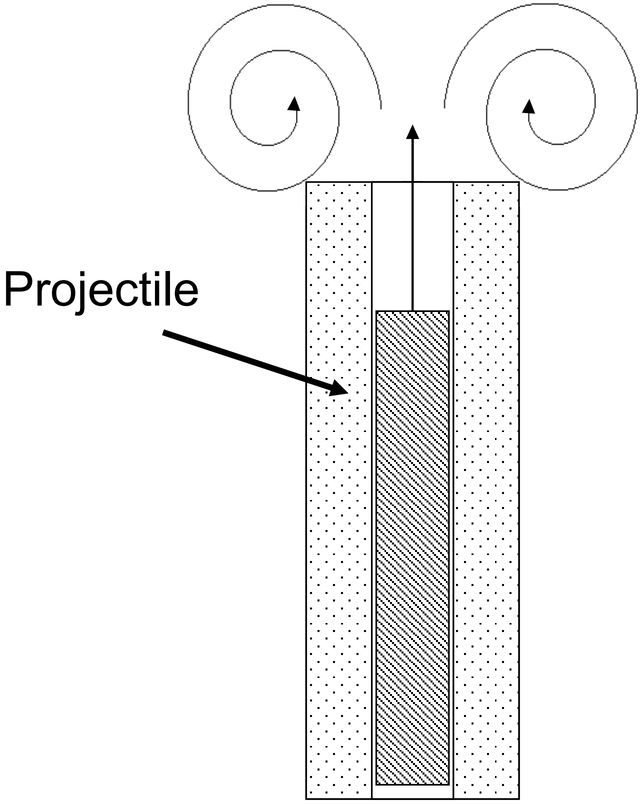
Gas Gun Method

- The projectile leaves the launcher under the force of expanding gases (i.e. gun launch)
- The driving gases are the source of cavitation nuclei
- Degree of supercavitation initiation is aspect ratio dependent – reattachment point is important

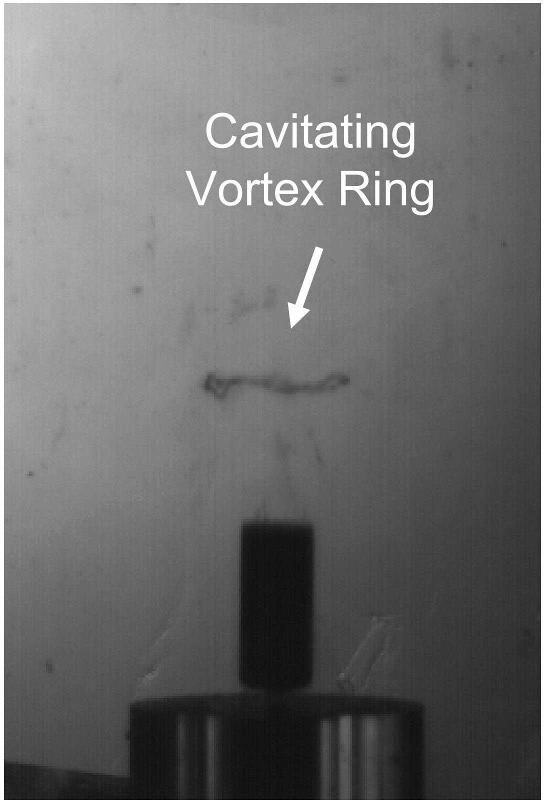




Vortex-Body Interaction



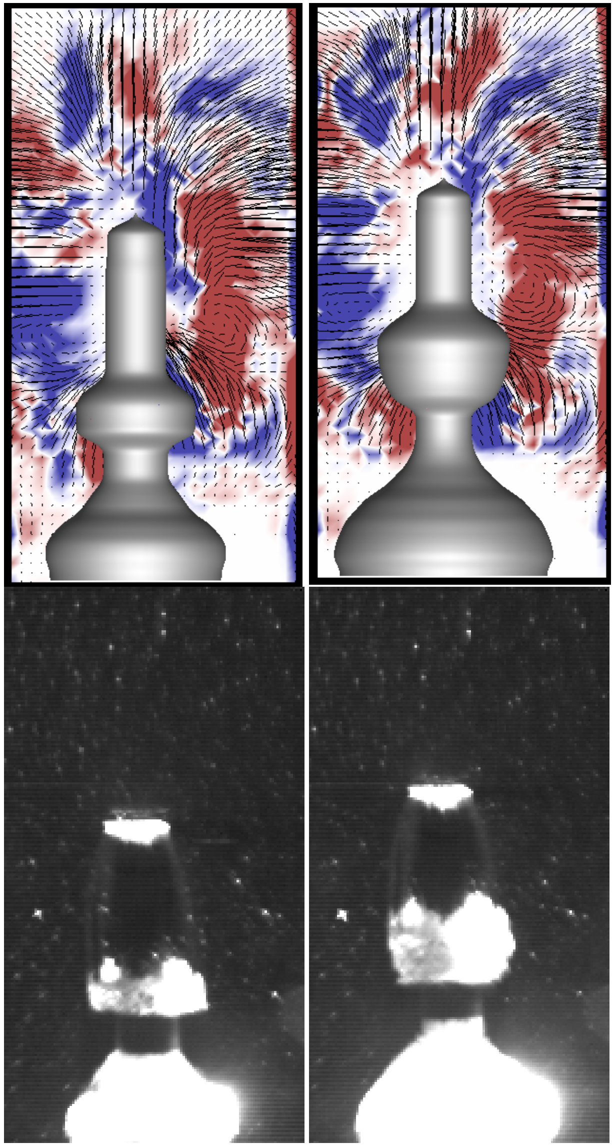
The formation of a vortex ring.



Generation of a cavitating vortex ring.

Interaction of the vortex ring and projectile.

Gas Gun Method



Blunt Cylindrical Projectile

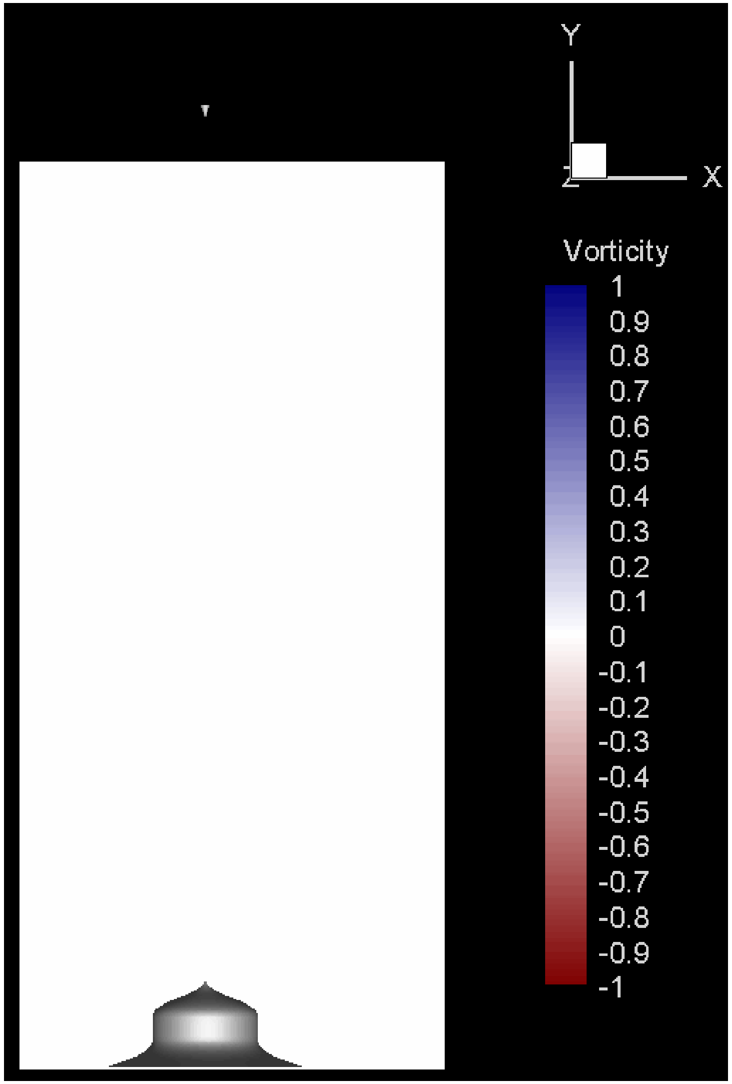
Aspect Ratio 5

U_0 = 27 m/s

σ = 0.29

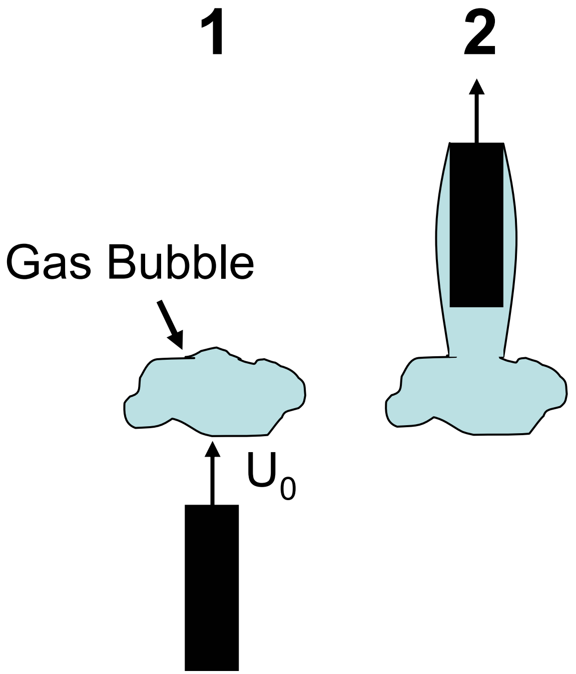
(not accounting for injected gas)

- A large degree of fluid structure interaction takes place
- Asymmetric vortices can cause instability in projectile flight



Gas Injection Method

- Pressurized gas is injected in the trajectory of the projectile prior to launch
- The supercavity is fully developed before the projectile interacts with the surrounding fluid



U_0 = 12 m/s

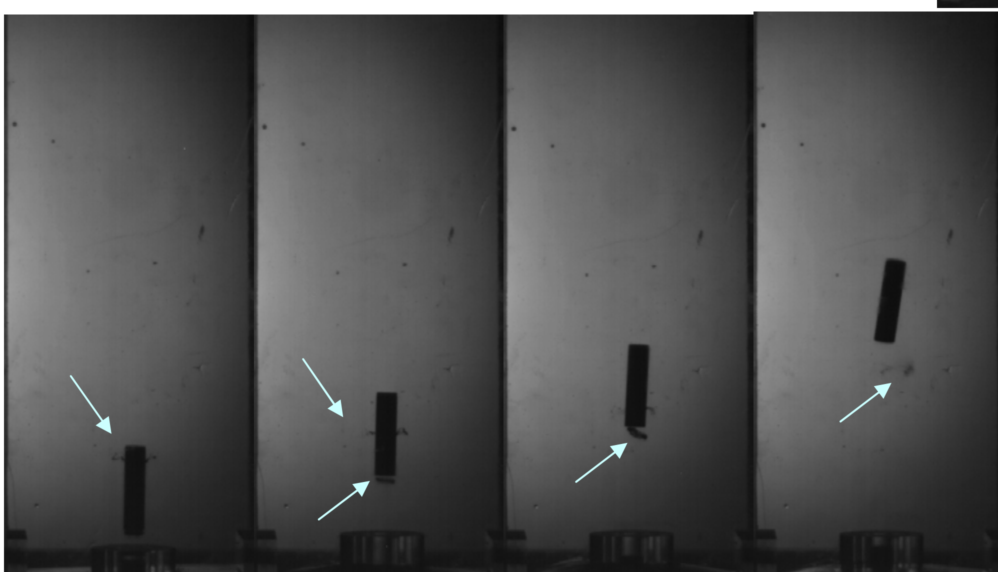
σ = 1.48 (not accounting for injected gas)

Gas Injection Effect

U_0 = 12.8 m/s

σ = 1.48

(not accounting for injected gas)



U_0 = 13.8 m/s

σ = 1.12

Gas Injection Method

Square Projectile

No Gas Injection

U_0 = 14.4 m/s , σ = 1.03

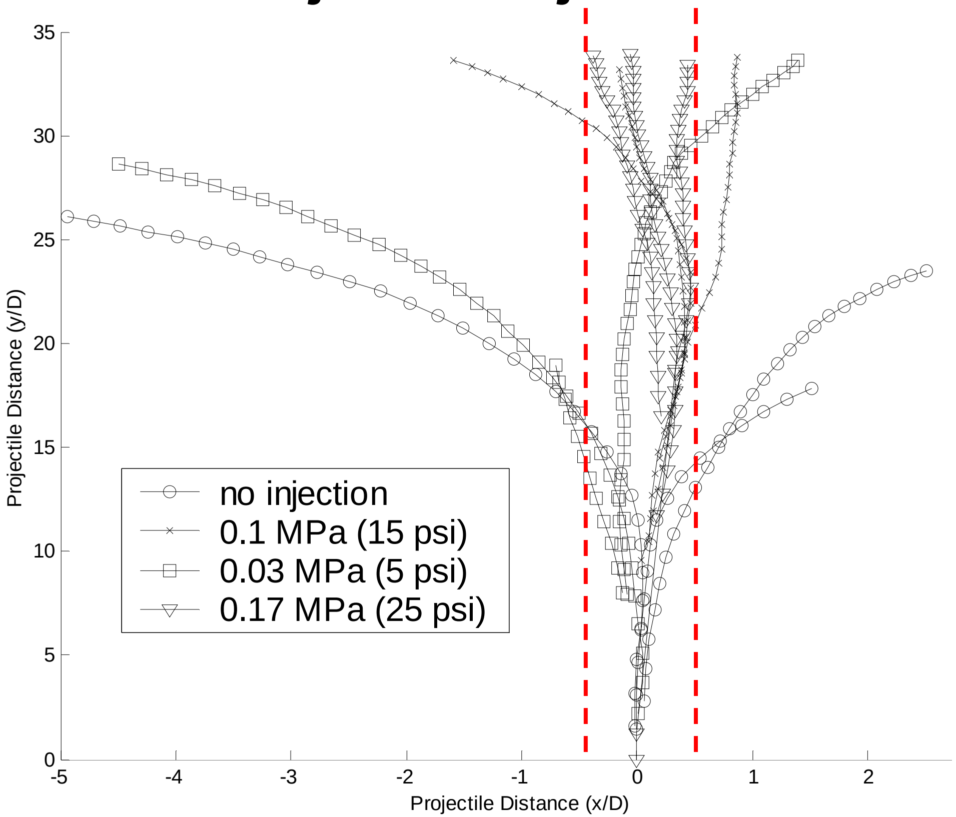
Square Projectile

Gas Injection

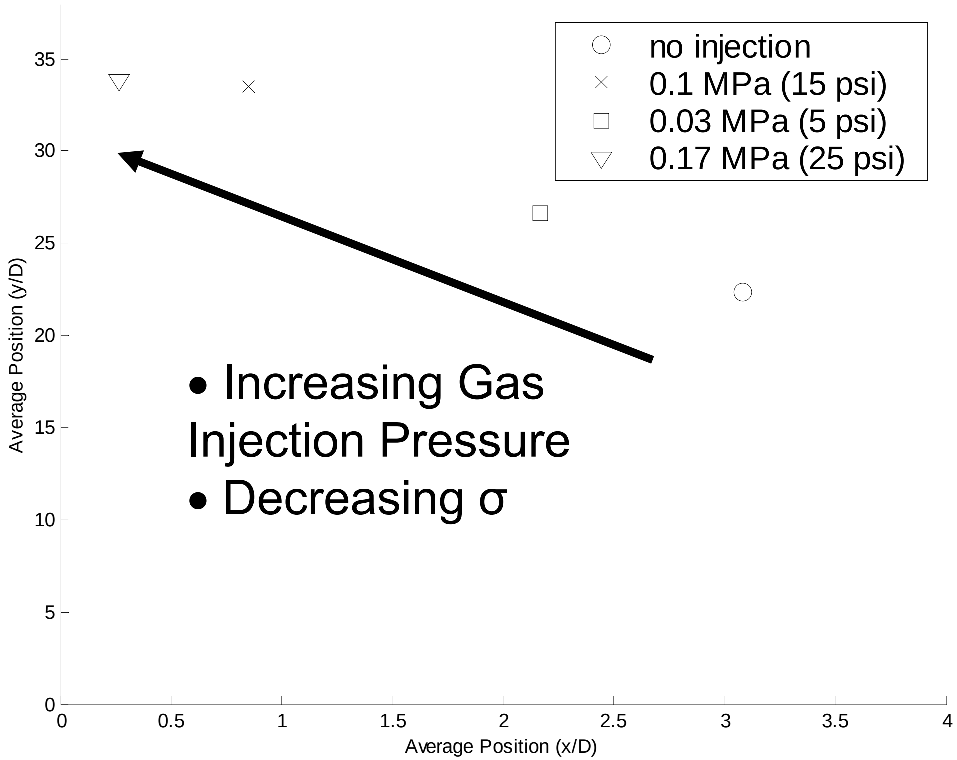
U_0 = 11.4 m/s ,σ = 1.64

Gas Injection Method

Projectile Trajectories



Average Projectile Ending Location



Higher Gas Injection Pressures Results in Stronger Cavity Development and Better Projectile Stability

Conclusions

- The gas injection method allows the projectile to reach a state of "instant supercavitation," thereby mitigating any fluid structure that could lead to its instability during launch
- The gas injection method allows supercavitation at greatly reduced speeds
- The gas injection method increases projectile lateral stability and decreases viscous drag