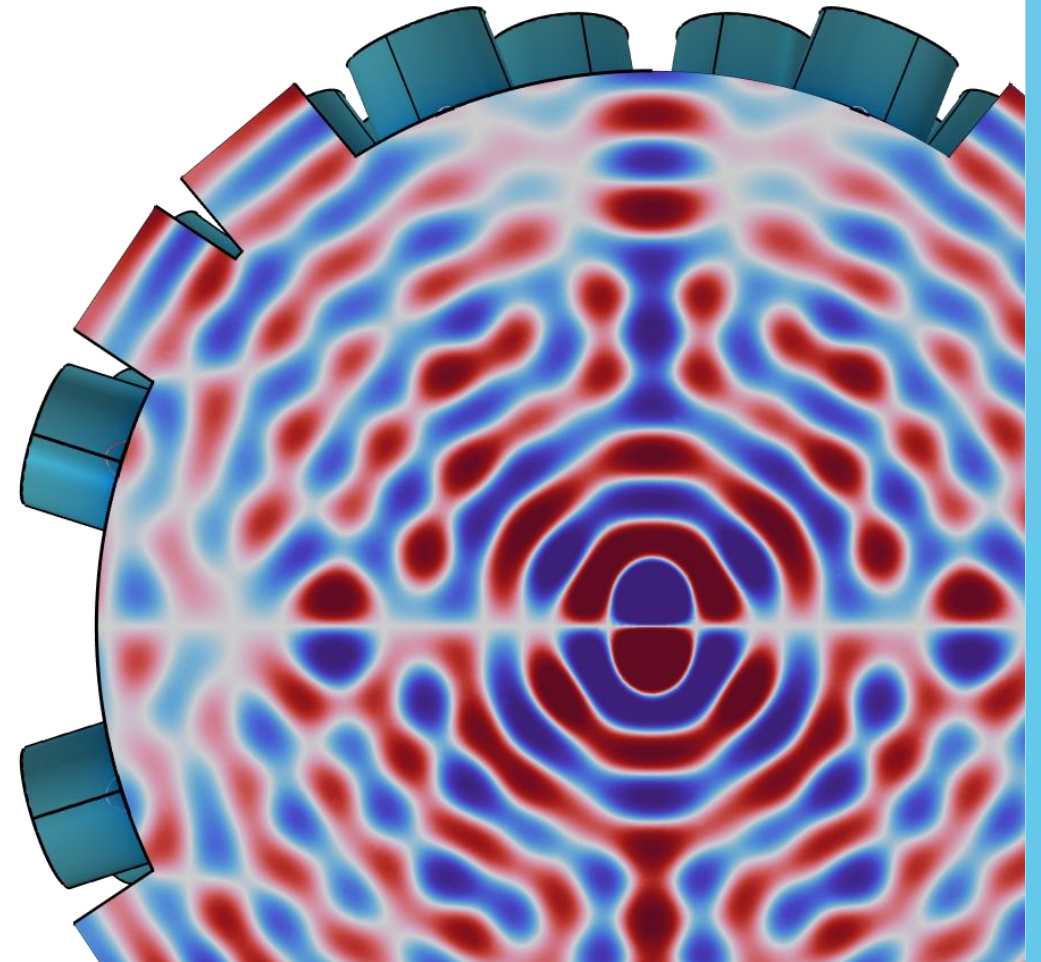
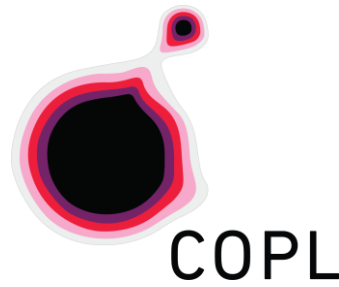


Acoustic Levitation of Magmatic Samples for (Exo)planetary Research

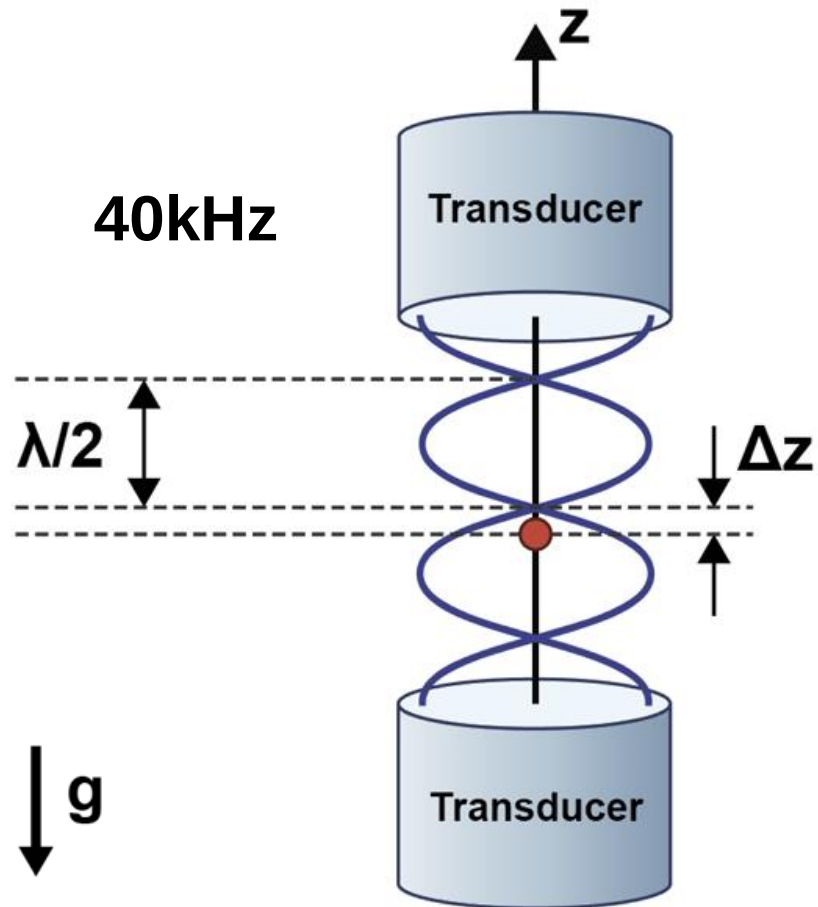
By Alex Korocencev

24th September 2026

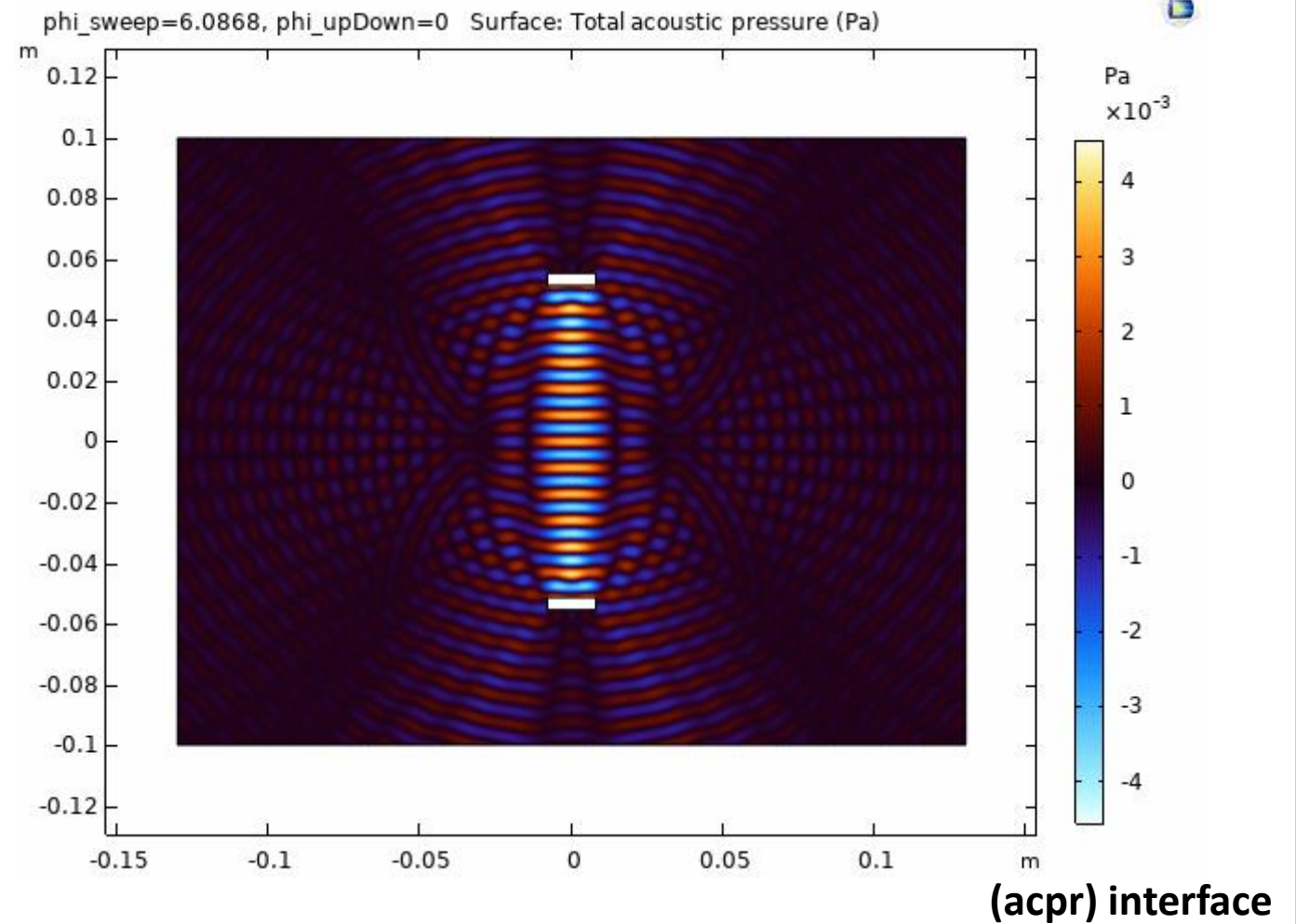
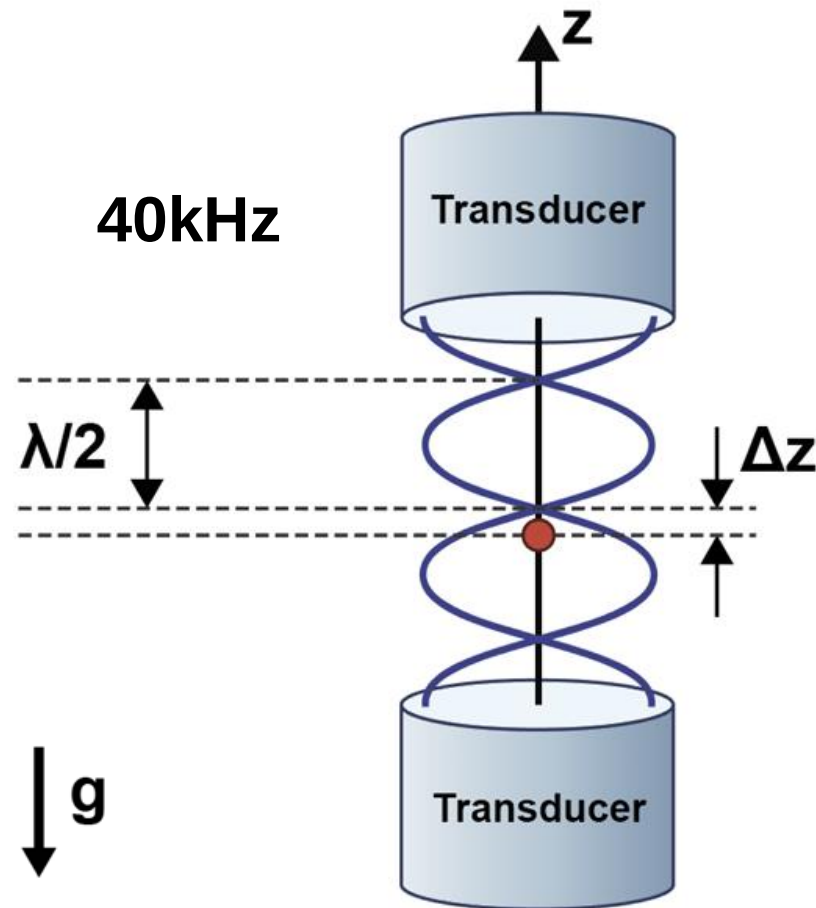
ETH zürich



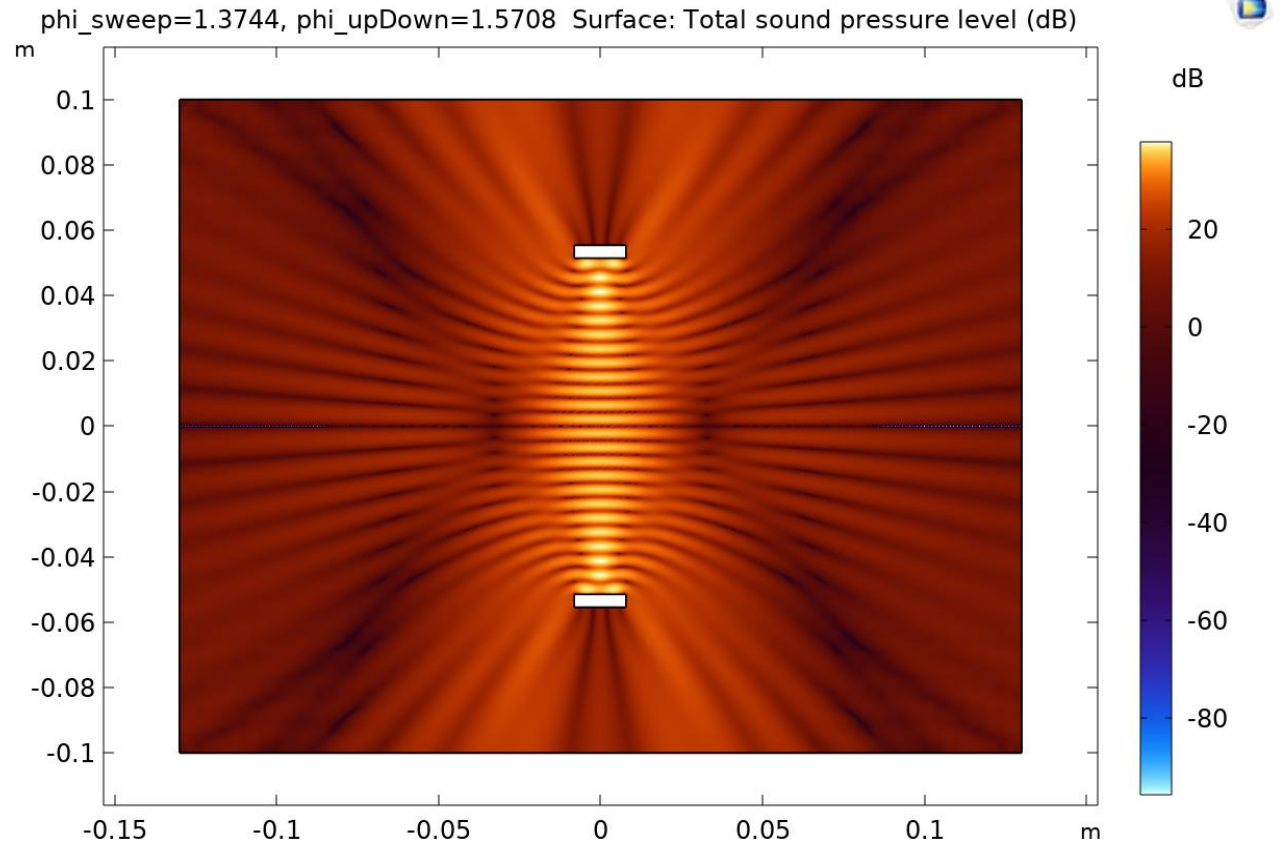
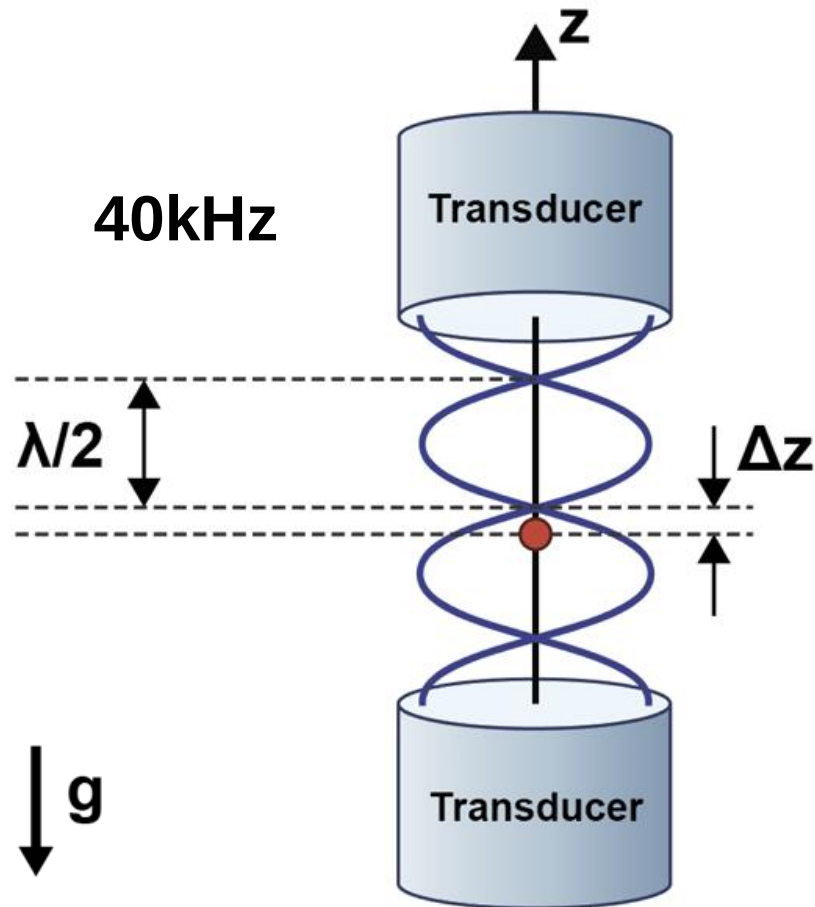
What is Acoustic Levitation?



What is Acoustic Levitation?

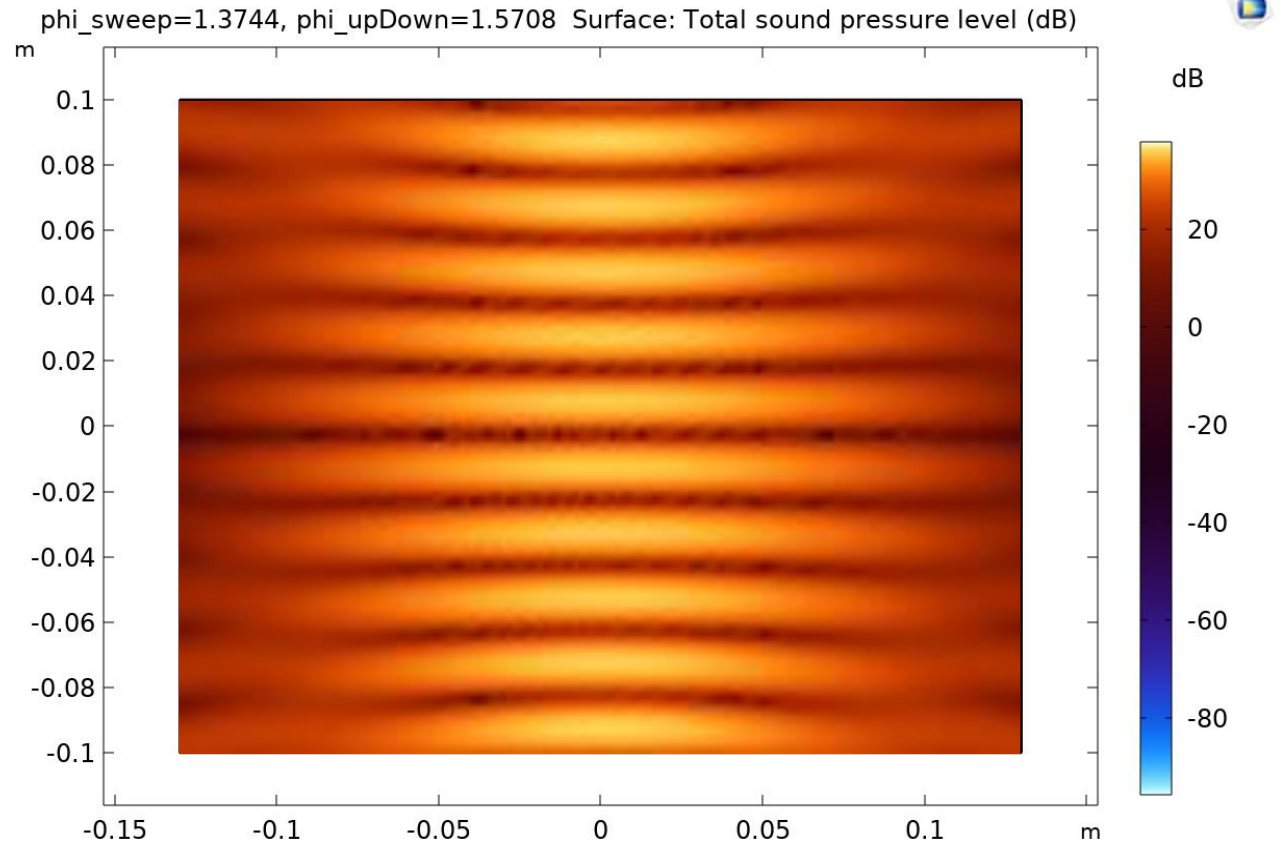
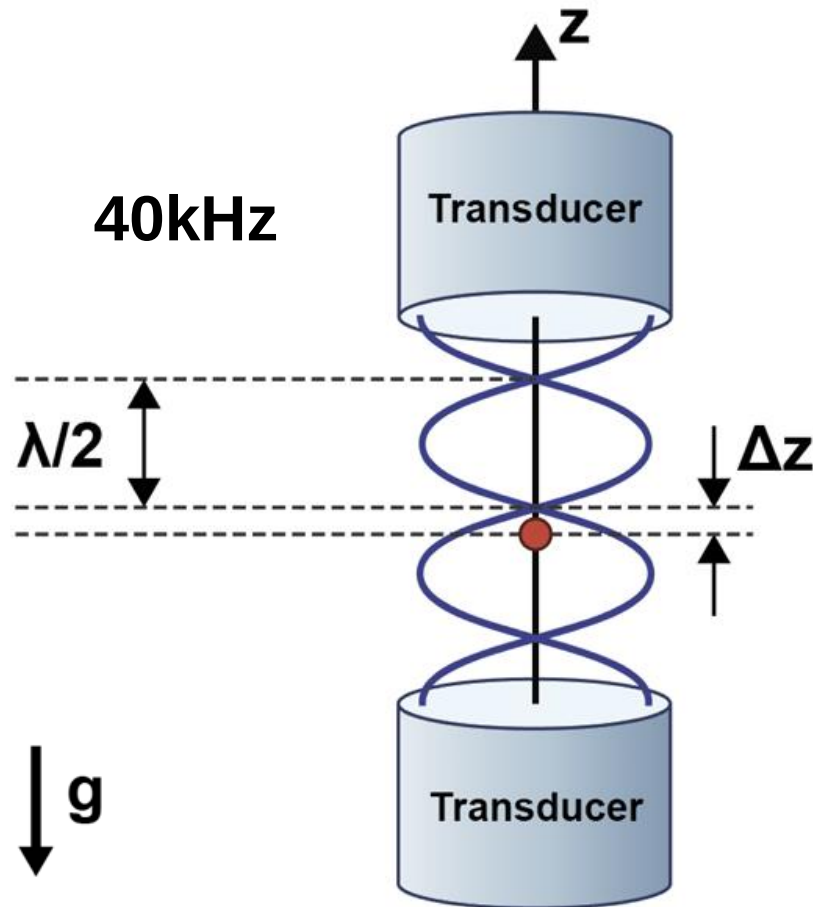


What is Acoustic Levitation?



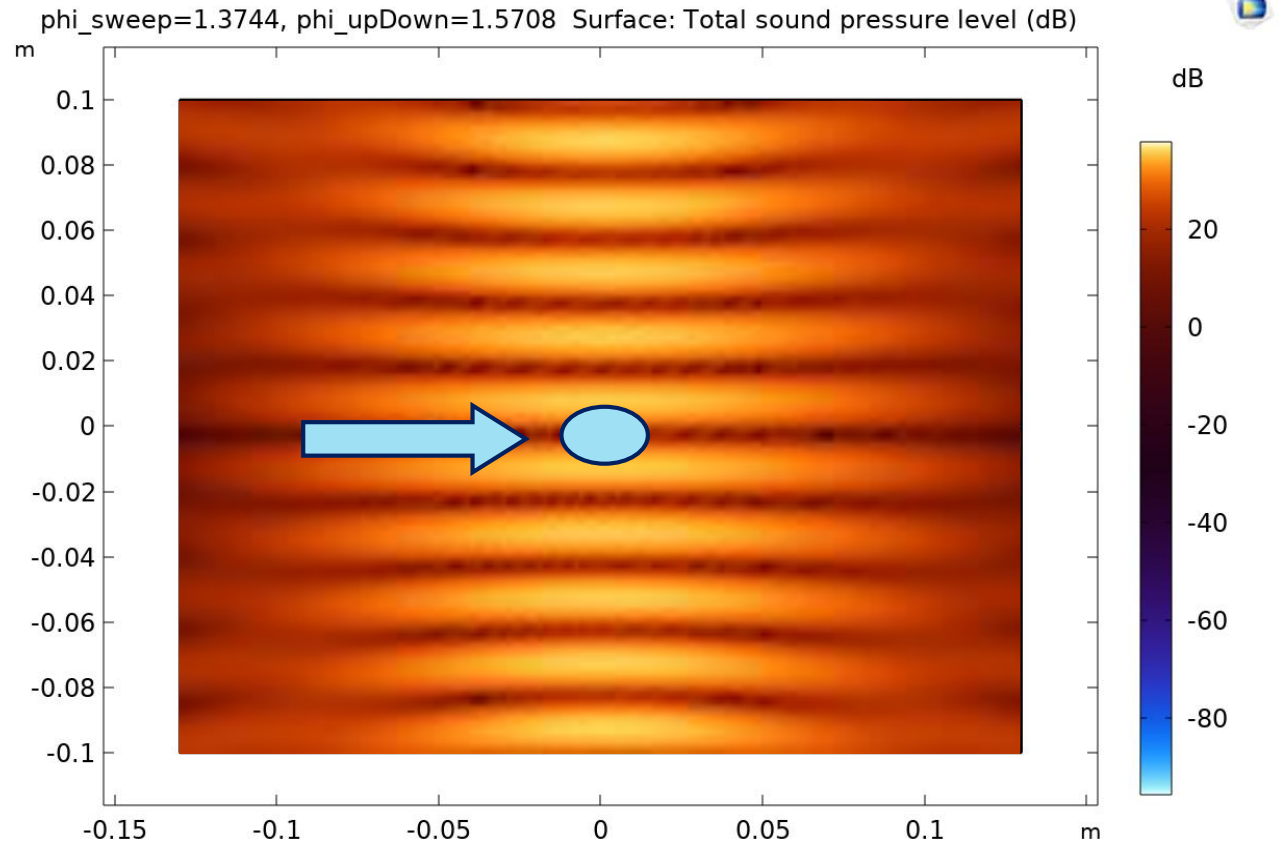
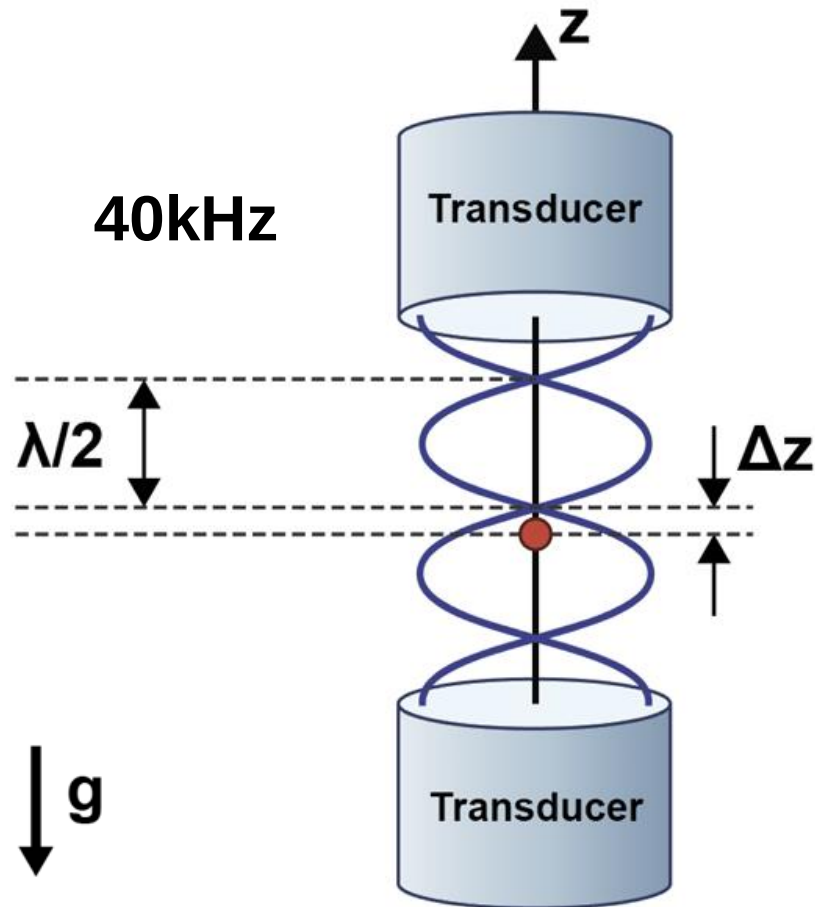
(acpr) interface

What is Acoustic Levitation?



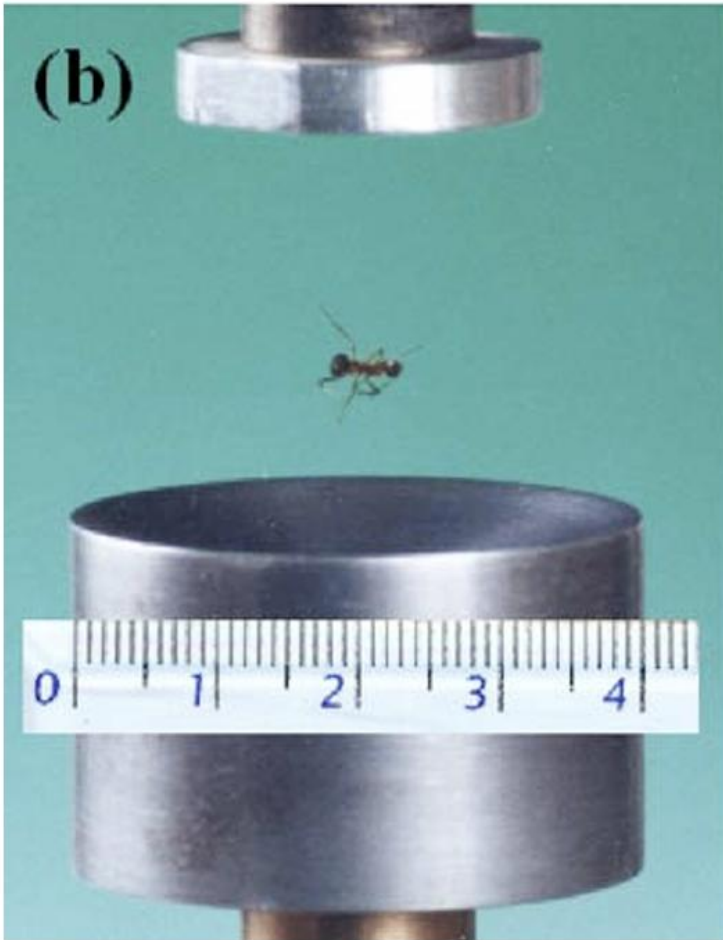
(acpr) interface

What is Acoustic Levitation?



(acpr) interface

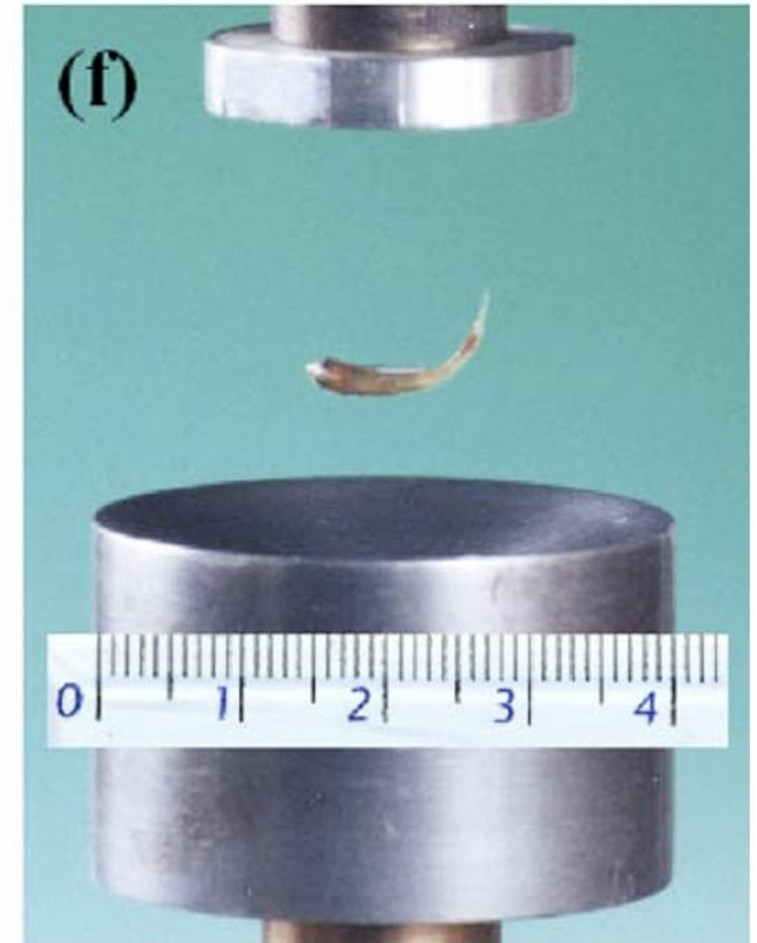
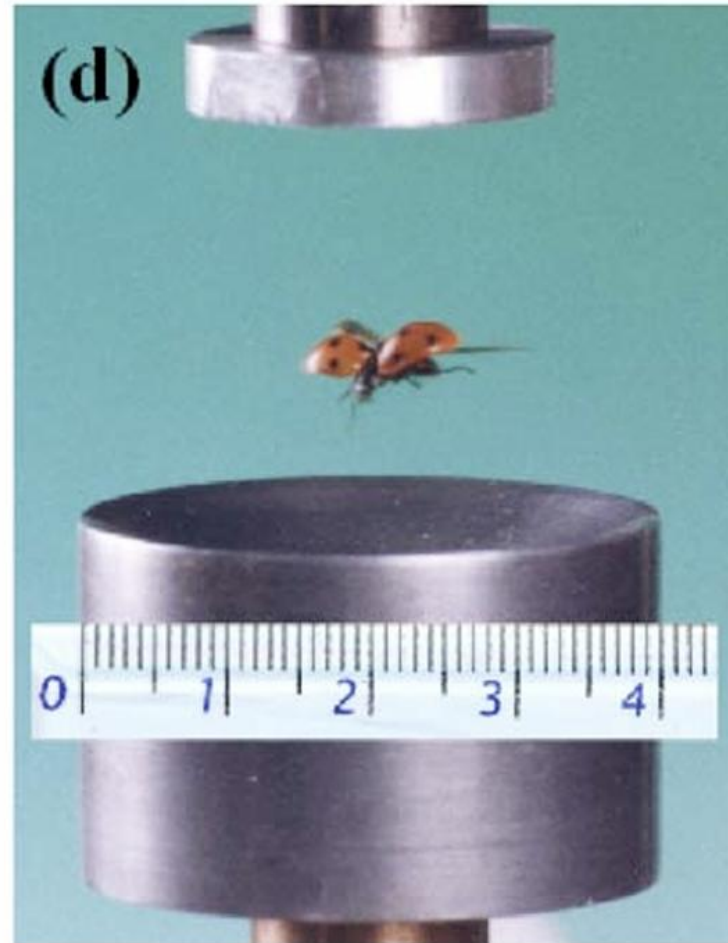
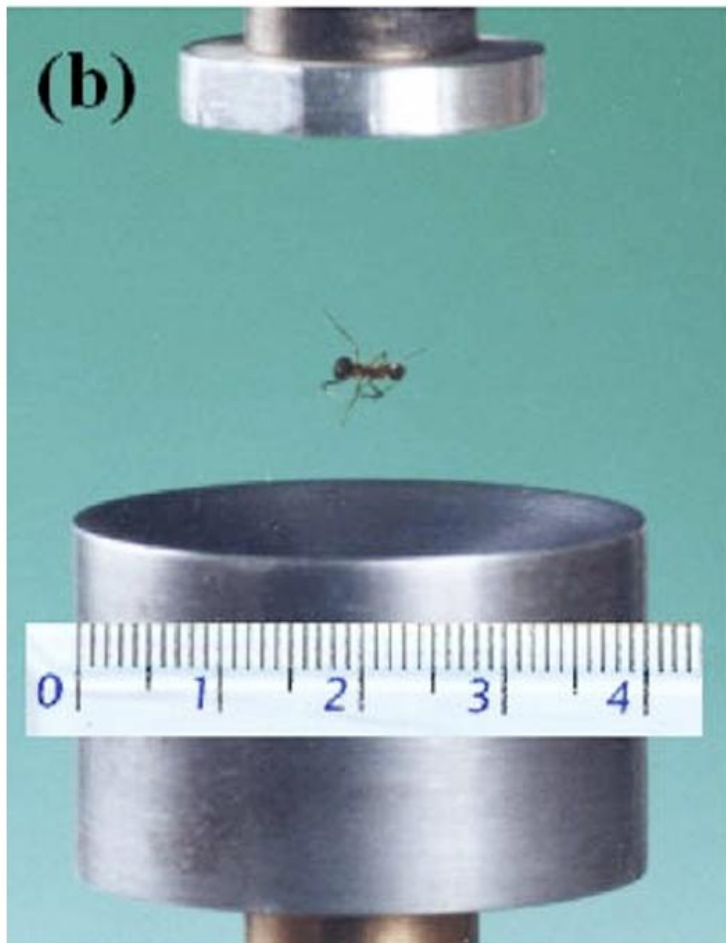
What is Acoustic Levitation?



What is Acoustic Levitation?

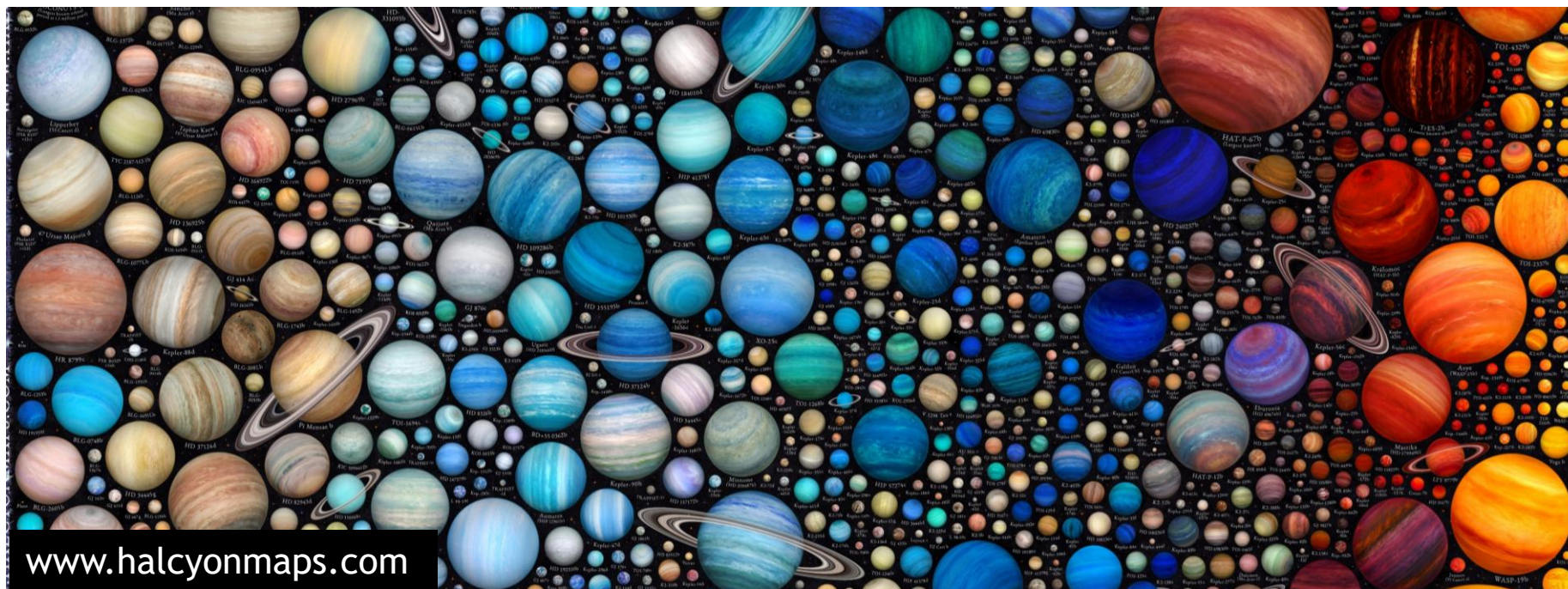


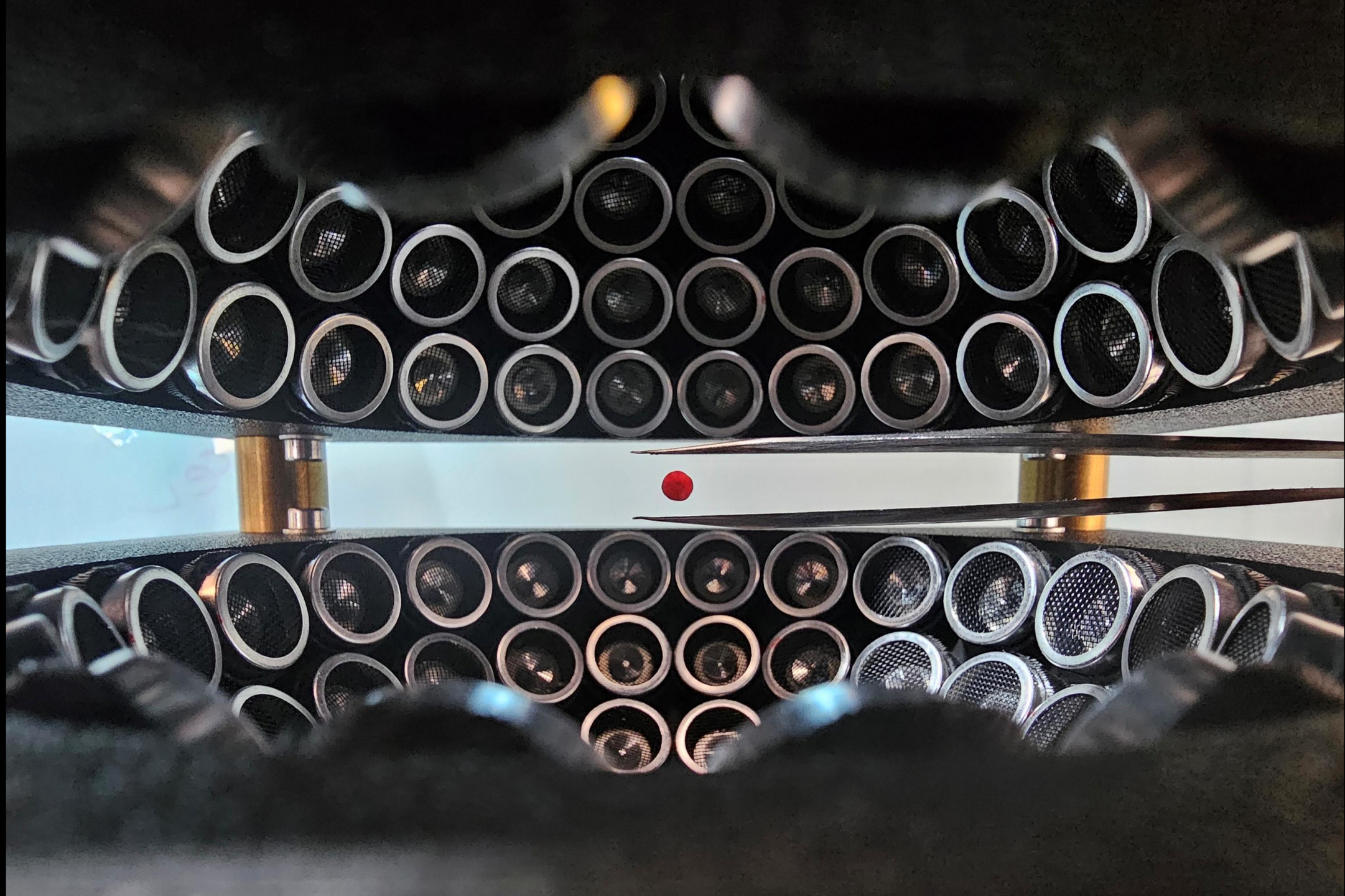
What is Acoustic Levitation?



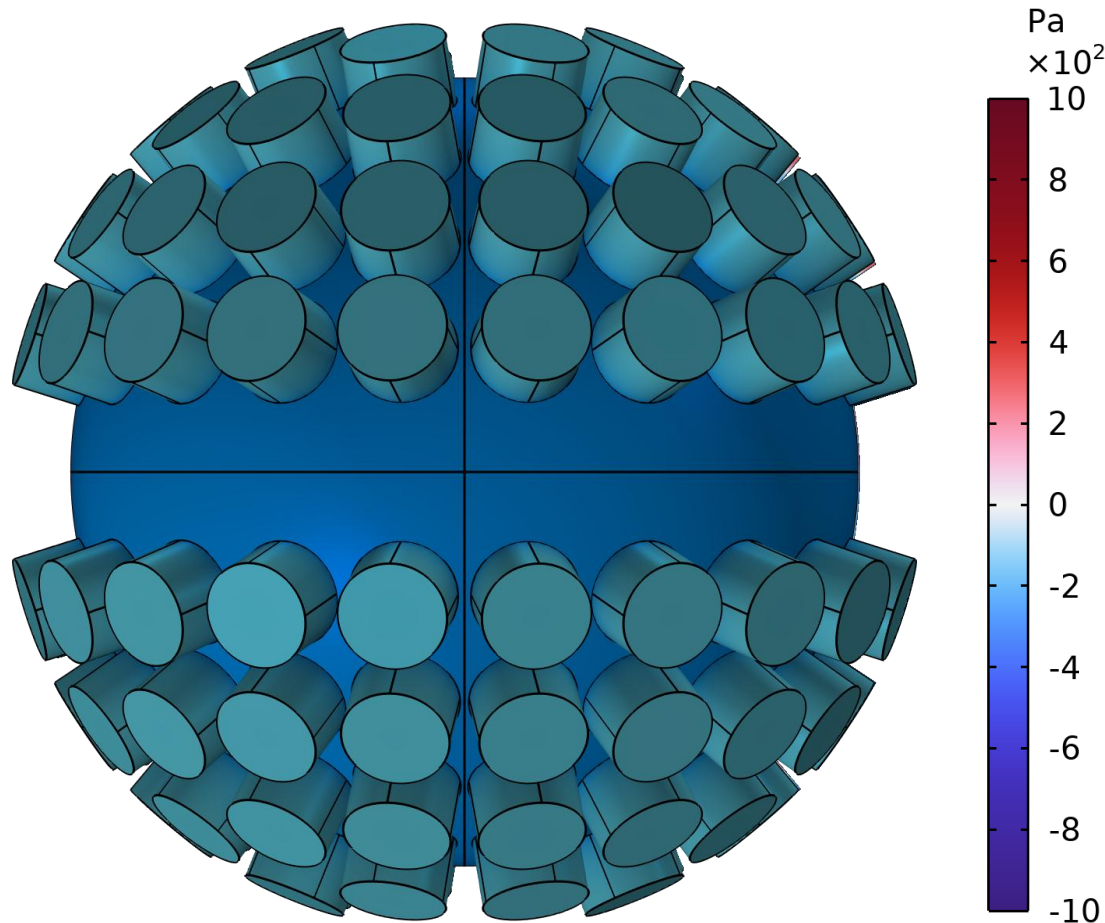
What do we want to levitate?

Lava droplets!
Why?





Acoustic Analysis



Step 1

- Build model using (acpr) interface in 3D
- Transducer -> Normal Acceleration Boundary
- Use Shifted Laplace Iterative Solver

Step 2

- Obtain Gor'kov Potential (in Results)

$$U = \frac{4}{3}R^3 \left(\frac{1}{2} \left(1 - \frac{\rho_0 c_0^2}{\rho_p c_p^2} \right) \frac{|p_1|^2}{\rho_0 c_0^2} - \frac{3}{4} \left(\frac{2(\rho_p - \rho_0)}{2\rho_p + \rho_0} \right) \rho_0 \left| -\frac{\nabla p_1}{i\omega\rho_0} \right|^2 \right),$$

U — Gor'kov potential; acoustic potential energy

R — Radius of the spherical sample

p_1 — First-order acoustic pressure field

ρ — Mass density

c — Speed of sound

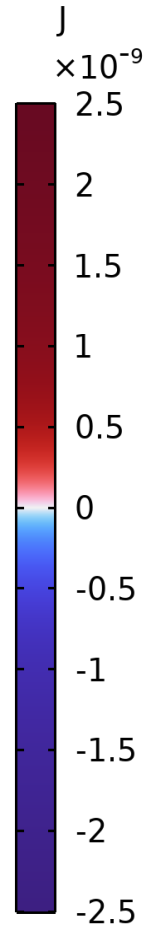
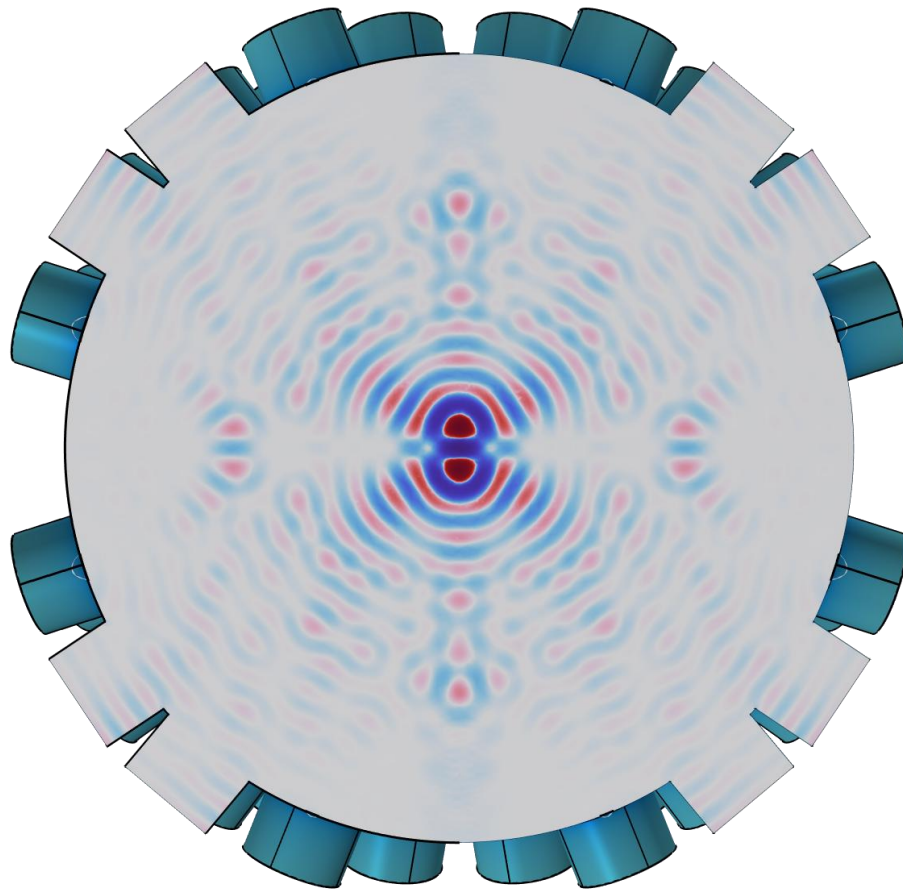
ω — Angular acoustic frequency

f — Acoustic frequency in hertz

ρ_0, c_0 — Properties of the host medium

ρ_p, c_p — Properties of the particle or sample

Acoustic Analysis



Step 1

- Build model using (acpr) interface in 3D
- Transducer -> Normal Acceleration Boundary
- Use Shifted Laplace Iterative Solver

Step 2

- Obtain Gor'kov Potential (in Results)

$$U = \frac{4}{3}R^3 \left(\frac{1}{2} \left(1 - \frac{\rho_0 c_0^2}{\rho_p c_p^2} \right) \frac{|p_1|^2}{\rho_0 c_0^2} - \frac{3}{4} \left(\frac{2(\rho_p - \rho_0)}{2\rho_p + \rho_0} \right) \rho_0 \left| -\frac{\nabla p_1}{i\omega\rho_0} \right|^2 \right),$$

U — Gor'kov potential; acoustic potential energy

R — Radius of the spherical sample

p_1 — First-order acoustic pressure field

ρ — Mass density

c — Speed of sound

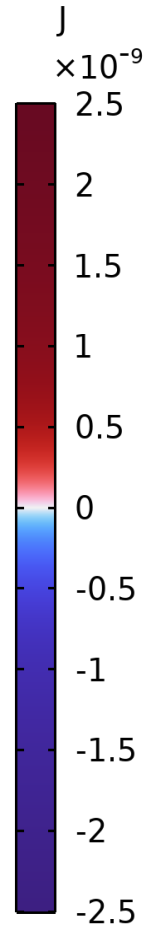
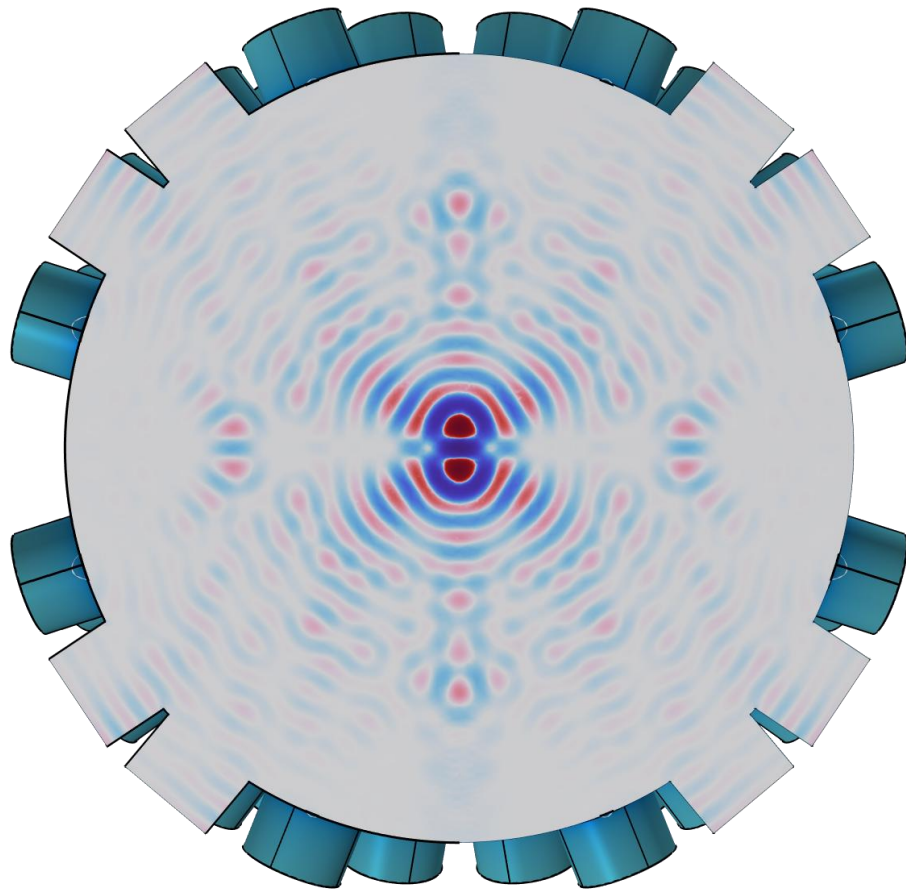
ω — Angular acoustic frequency

f — Acoustic frequency in hertz

ρ_0, c_0 — Properties of the host medium

ρ_p, c_p — Properties of the particle or sample

Acoustic Analysis



Step 1

- Build model using (acpr) interface in 3D
- Transducer -> Normal Acceleration Boundary
- Use Shifted Laplace Iterative Solver

Step 2

- Obtain Gor'kov Potential (in Results)

$$U = \frac{4}{3}R^3 \left(\frac{1}{2} \left(1 - \frac{\rho_0 c_0^2}{\rho_p c_p^2} \right) \frac{|p_1|^2}{\rho_0 c_0^2} - \frac{3}{4} \left(\frac{2(\rho_p - \rho_0)}{2\rho_p + \rho_0} \right) \rho_0 \left| -\frac{\nabla p_1}{i\omega\rho_0} \right|^2 \right),$$

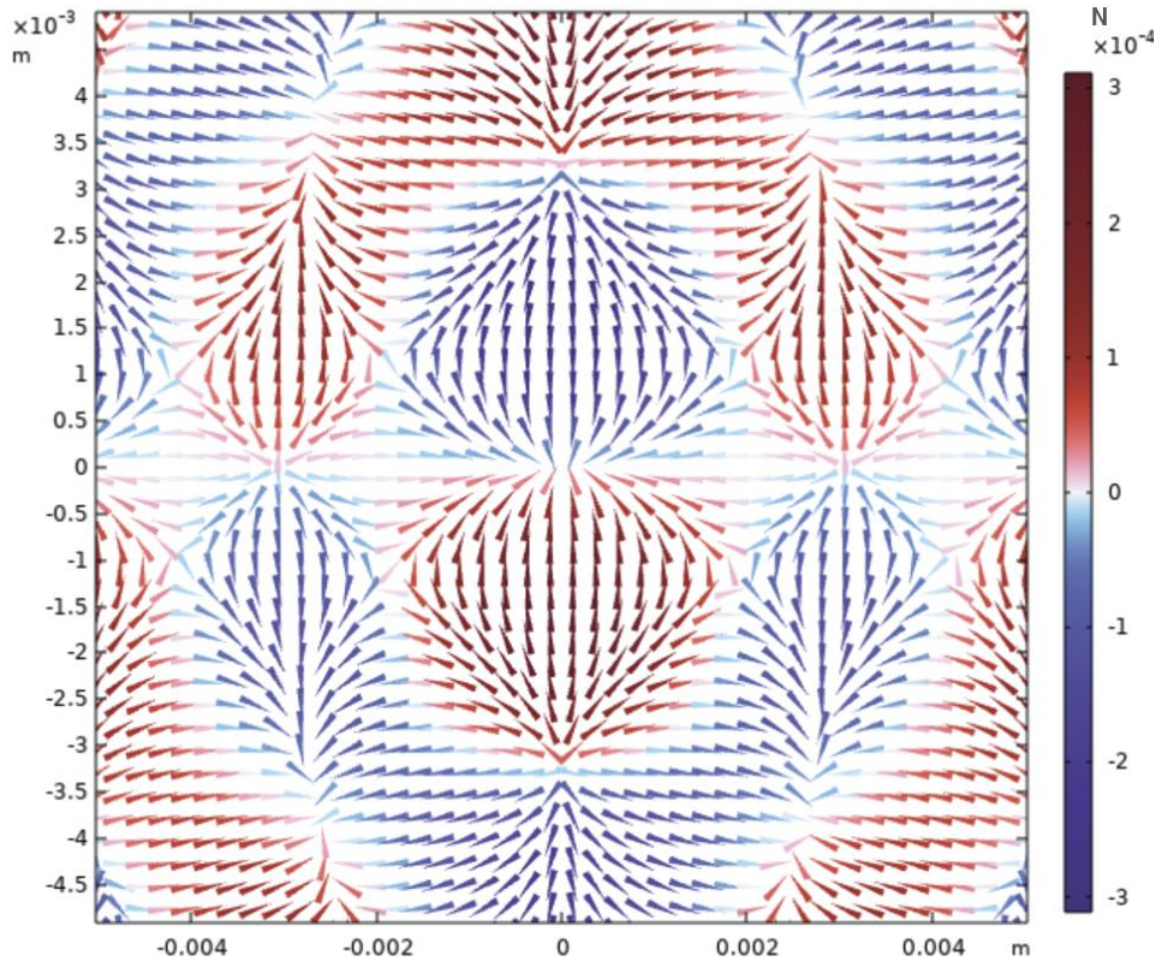
Step 3

- Evaluate force field

$$\mathbf{F}_{\text{rad}} = -\nabla U$$

Acoustic Analysis

Force Vector Field



Step 1

- Build model using (acpr) interface in 3D
- Transducer -> Normal Acceleration Boundary
- Use Shifted Laplace Iterative Solver

Step 2

- Obtain Gor'kov Potential (in Results)

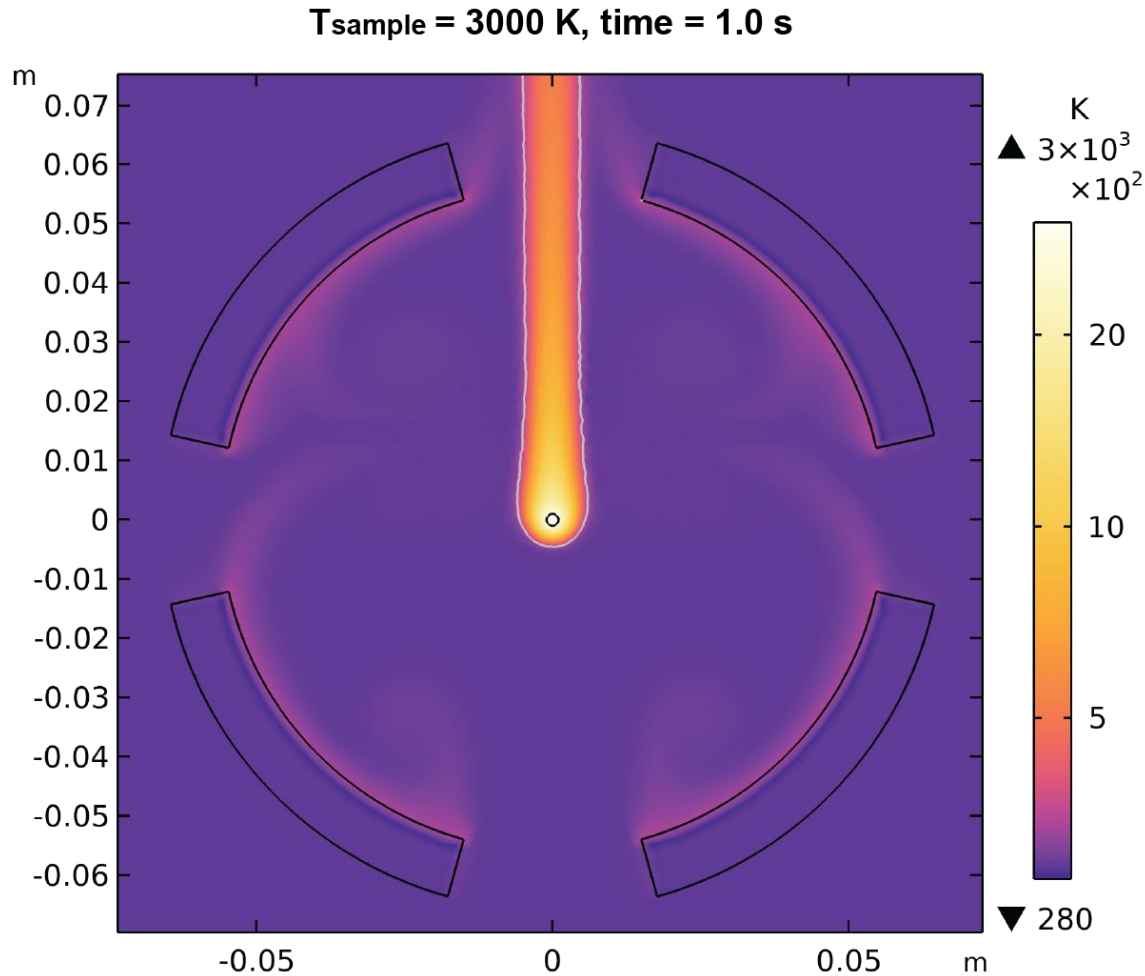
$$U = \frac{4}{3}R^3 \left(\frac{1}{2} \left(1 - \frac{\rho_0 c_0^2}{\rho_p c_p^2} \right) \frac{|p_1|^2}{\rho_0 c_0^2} - \frac{3}{4} \left(\frac{2(\rho_p - \rho_0)}{2\rho_p + \rho_0} \right) \rho_0 \left| -\frac{\nabla p_1}{i\omega\rho_0} \right|^2 \right),$$

Step 3

- Evaluate force field

$$\mathbf{F}_{\text{rad}} = -\nabla U$$

Thermal Analysis



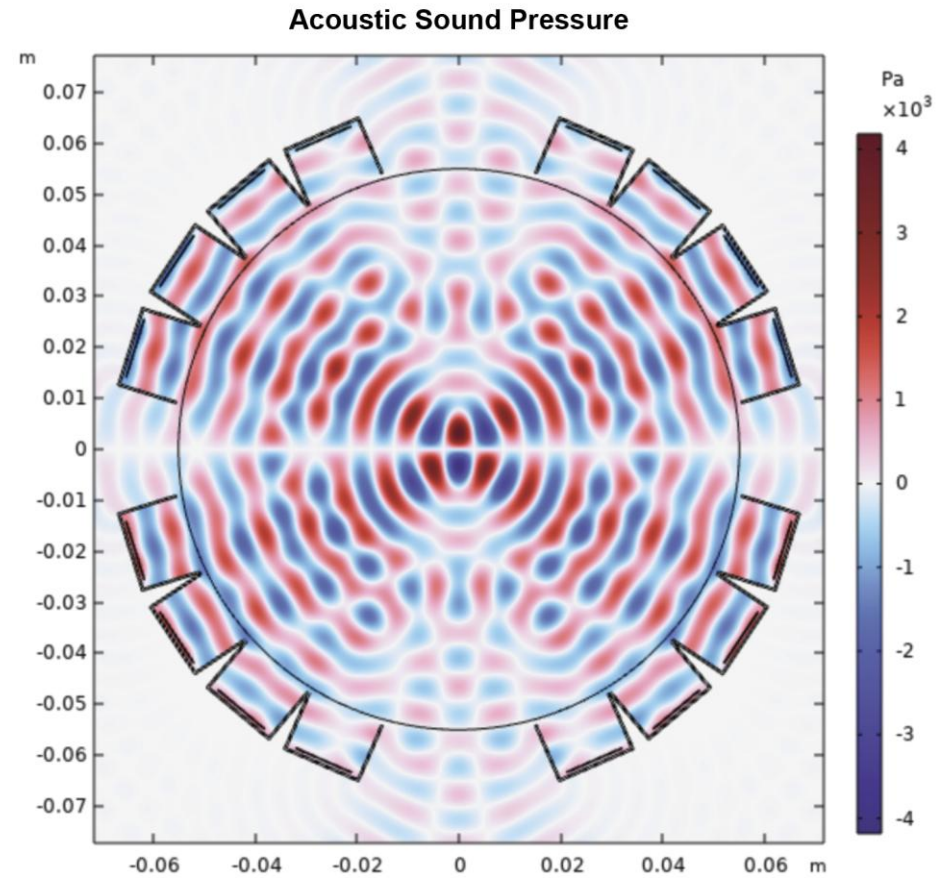
Physics Interfaces

- Heat Transfer in Fluids (ht)
- Laminar Flow (spf)
- Surface-to-Surface Radiation (rad)

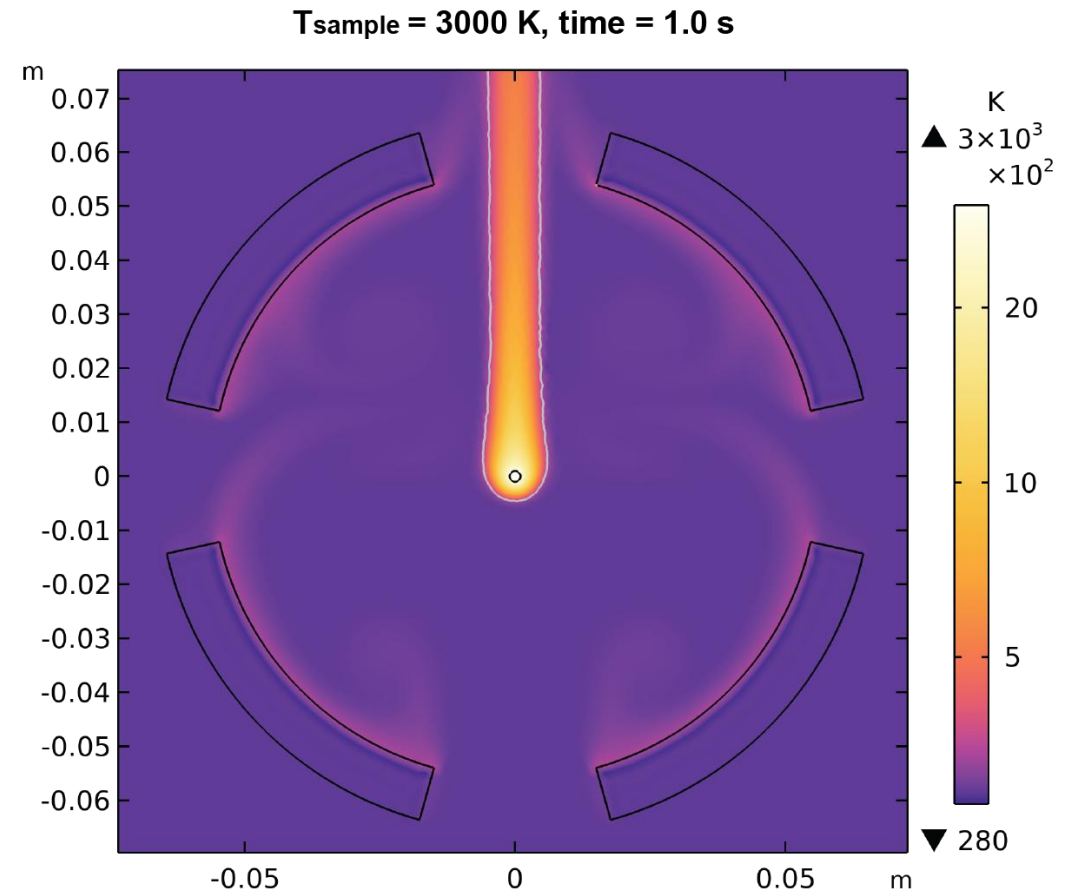
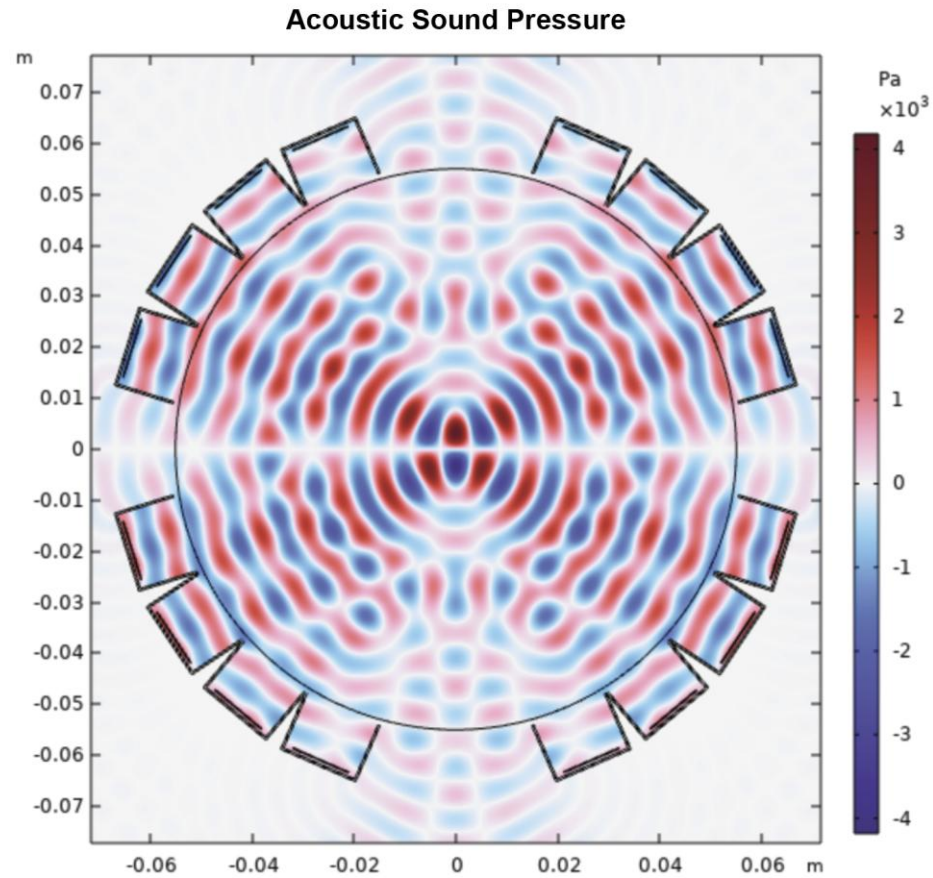
Multiphysics Interfaces

- Nonisothermal Flow (nitf)
- Heat Transfer with Surface-to-Surface Radiation (htrrad)

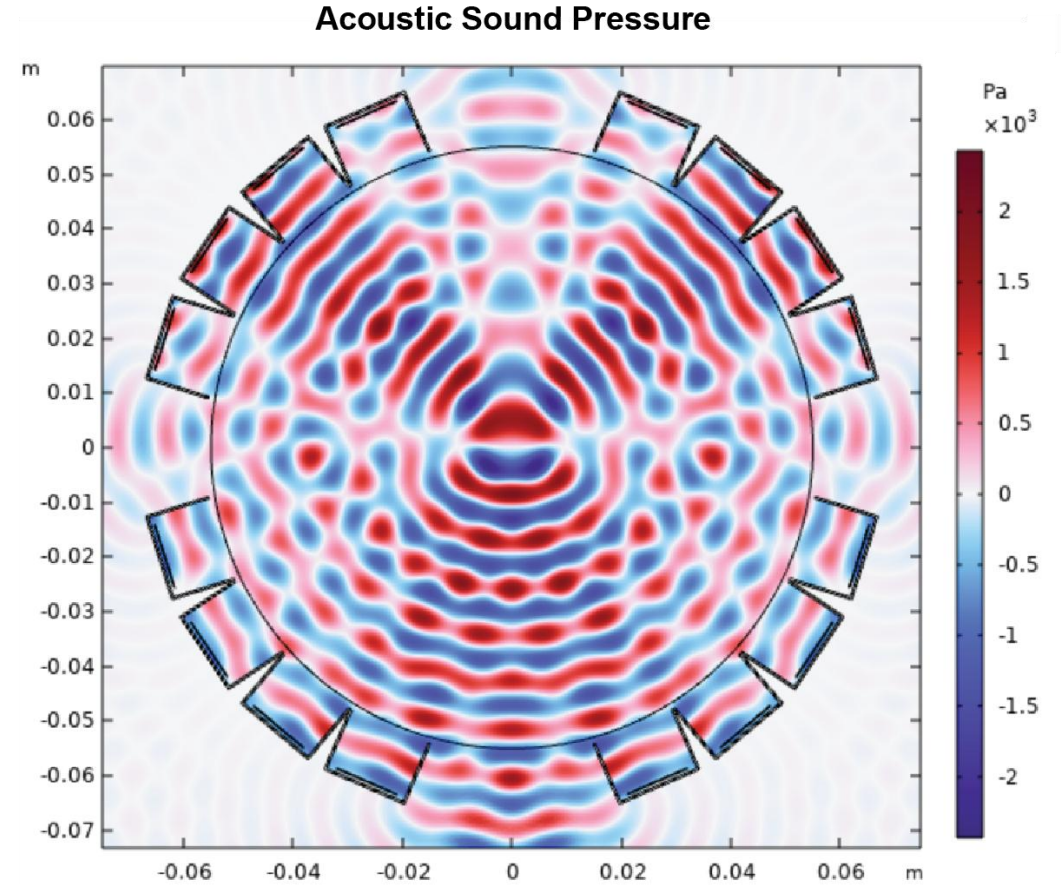
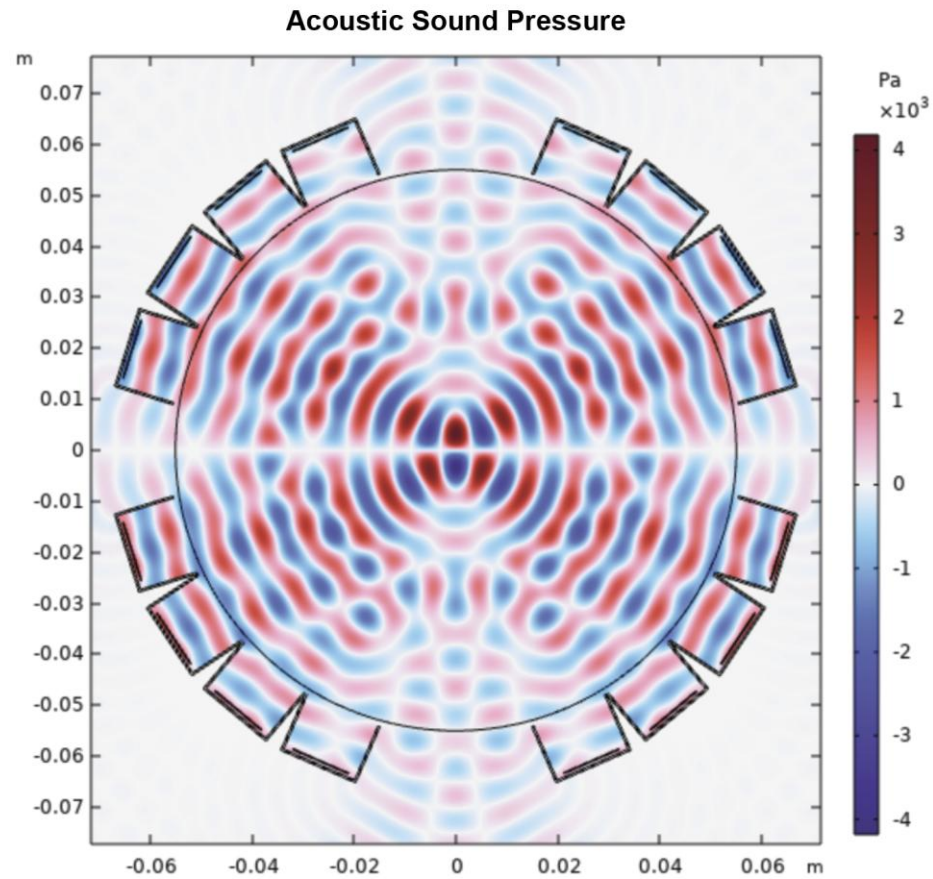
Obtained Results



Obtained Results



Obtained Results



Conclusions

- Levitation stable as long as thermal plume is vertical.
- Levitation weakens with increased temperature
- Levitation improves under higher air pressure

