

# The Mechanism of Shrimpluminescence

Tyler C. Sterling



# Snapping shrimp

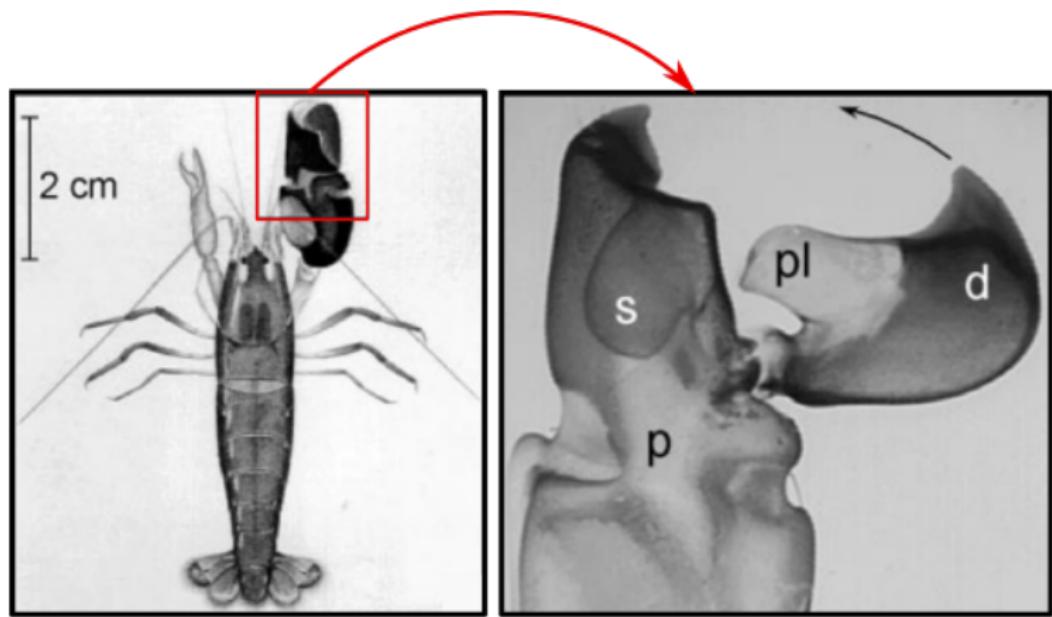


Figure: Adapted from Versluis et al. 2000

# How do they snap?

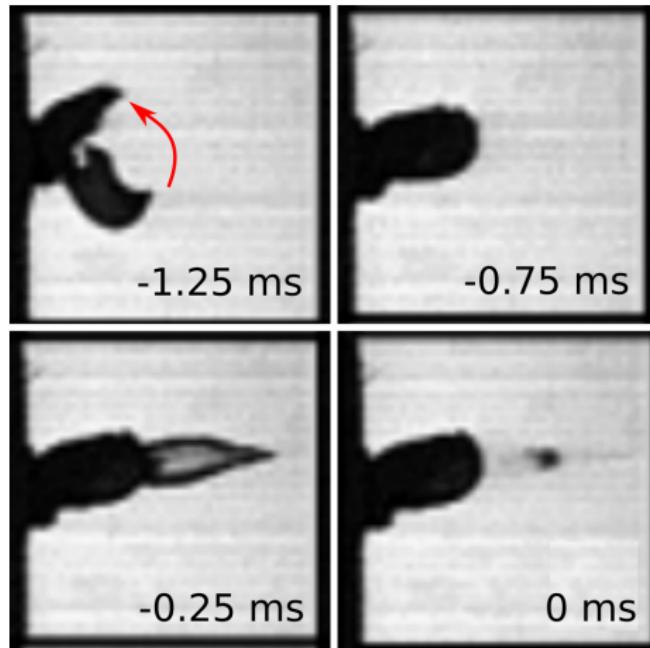


Figure: Adapted from Versluis et al. 2000

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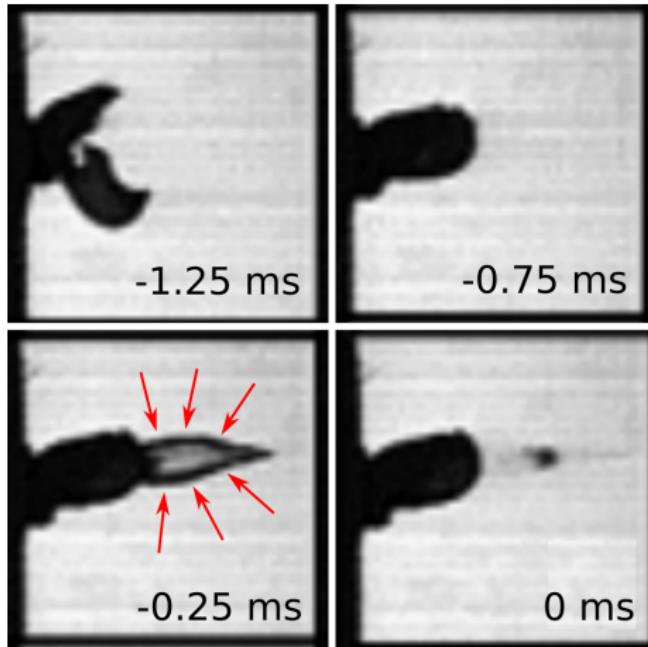


Figure: Adapted from Versluis et al. 2000

# How do they snap?

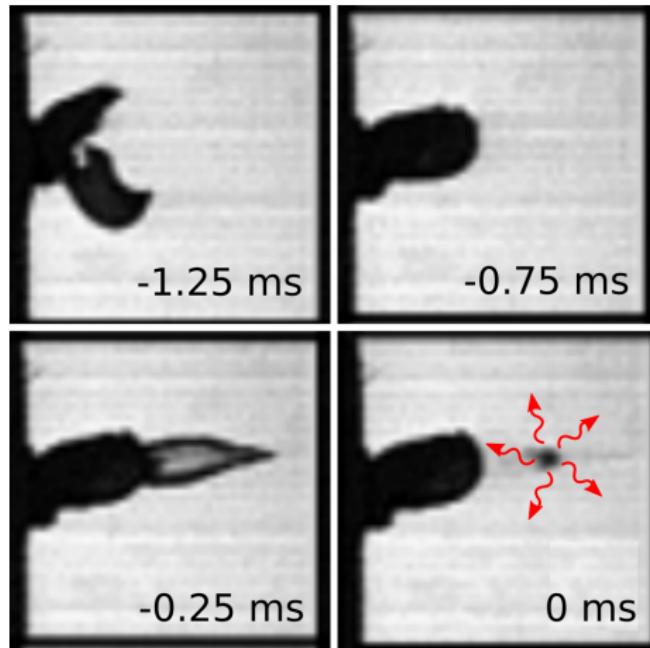


Figure: Adapted from Versluis et al. 2000

# Sonoluminescence

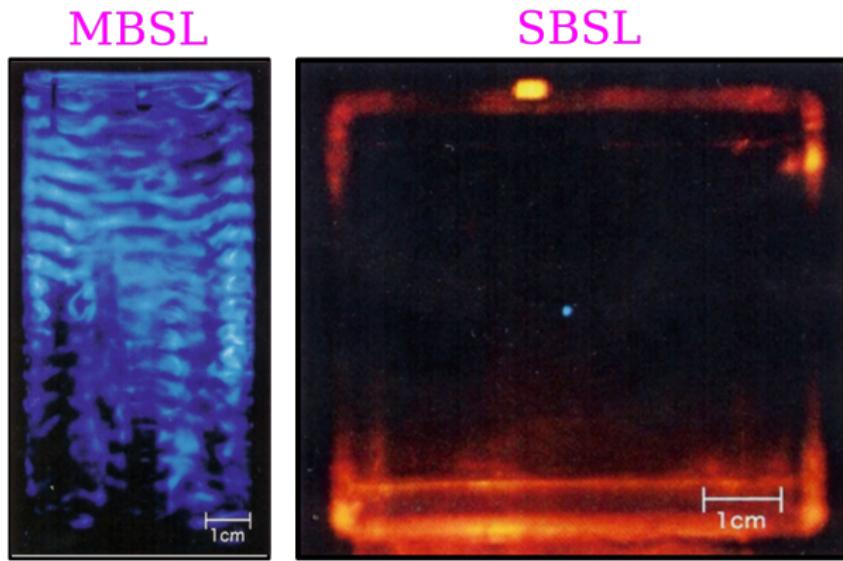


Figure: Adapted from Yasui 2018

# Multi-bubble sonoluminescence (MBSL)

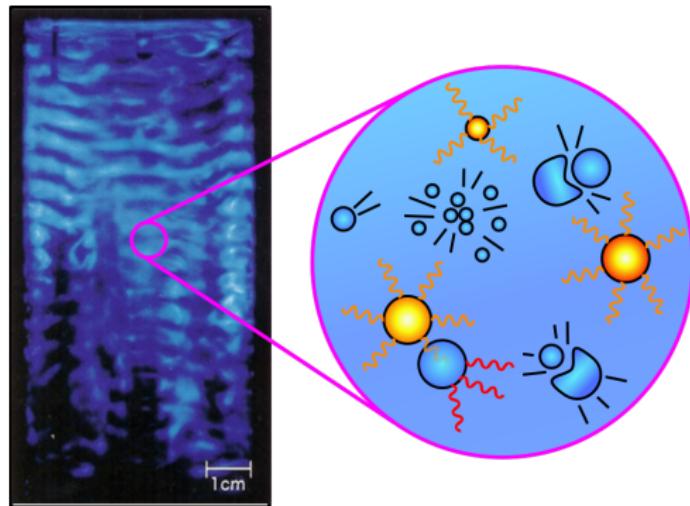


Figure: Adapted from Yasui 2018

# Single-bubble sonoluminescence (SBSL)

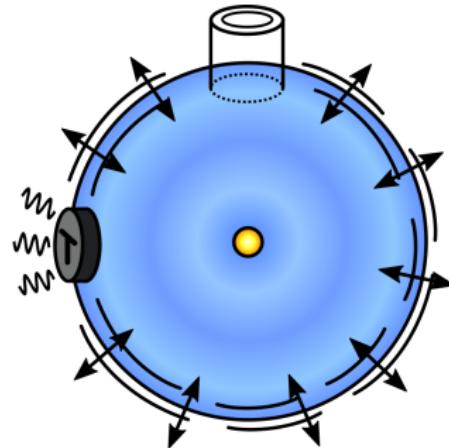
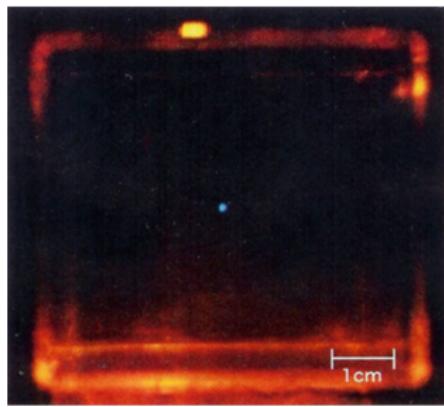


Figure: Adapted from Yasui 2018

“the hydrogen atom of sonoluminescence”<sup>1</sup>

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<sup>1</sup>Brenner, Hilgenfeldt, and Lohse 2002.

# Stable SBSL

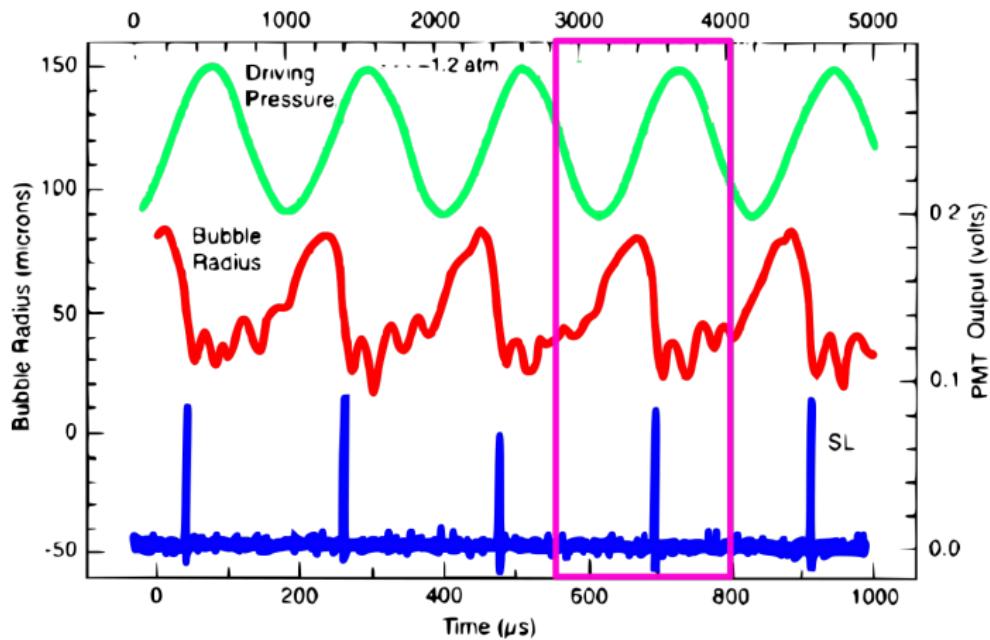
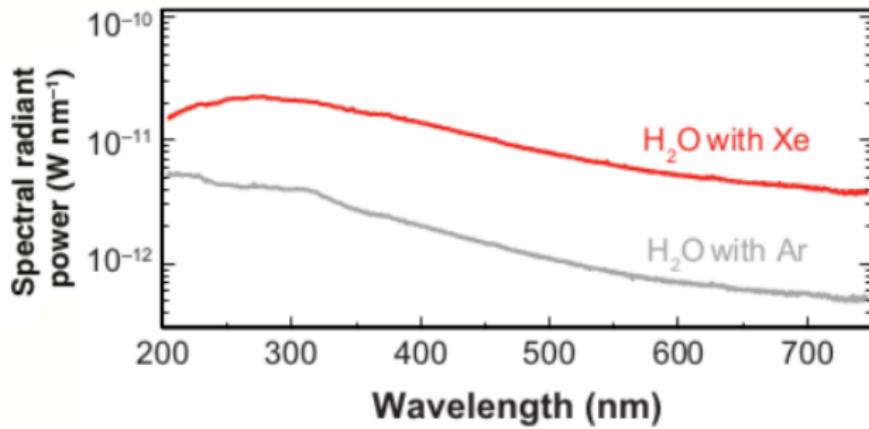


Figure: Adapted from Brenner, Hilgenfeldt, and Lohse 2002

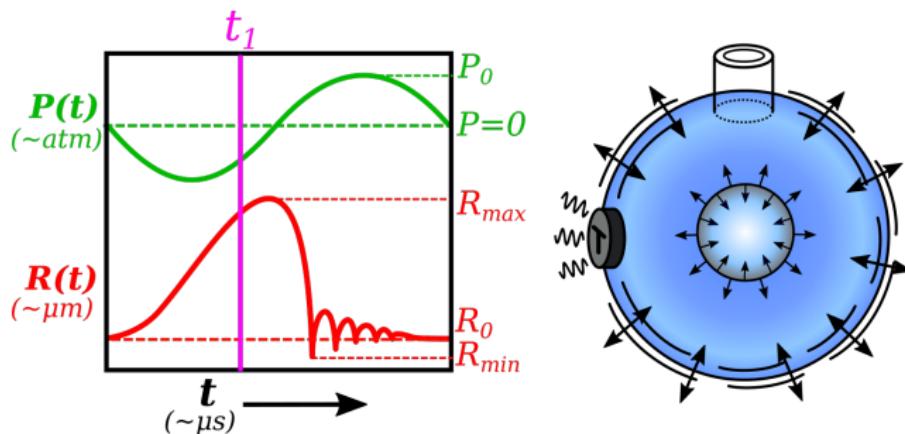
# The light spectrum



“...featureless spectra of unknown origin” <sup>2</sup>

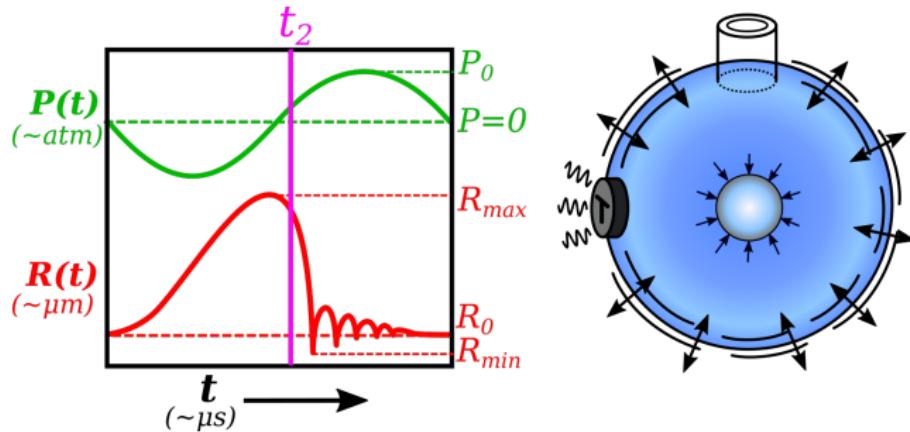
<sup>2</sup>Figure and quote from Suslick and Flannigan 2008

# Bubble dynamics: expansion



$$\underbrace{\rho(R\ddot{R} + \frac{3}{2}\dot{R}^2)}_{\text{"kinetic energy"}} = \underbrace{p_g(t) - P_a \sin(\omega t) - \frac{2\sigma}{R}}_{\text{"work}} + \dots$$

# Bubble dynamics: cavitation

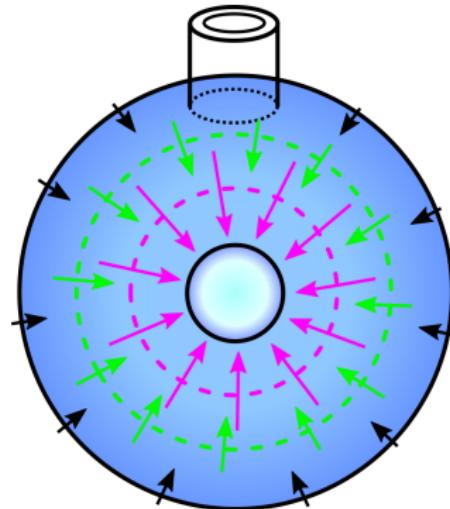


$$\dot{R} \sim \left(1 - \frac{t}{\tau}\right)^{-3/5}$$

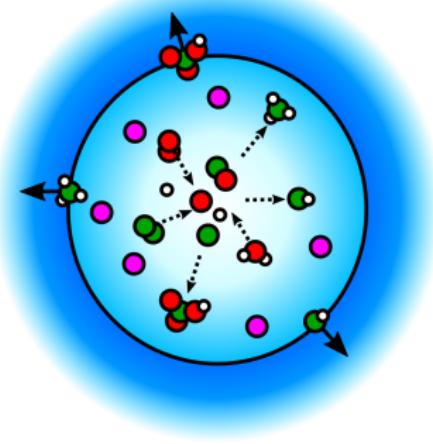
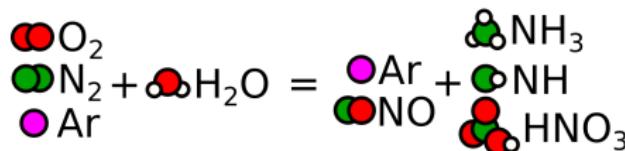
## Interlude: cavitation

$$\rho_0 4\pi R_1^2 \cdot u(R_1) \equiv \rho_0 4\pi R_2^2 \cdot u(R_2)$$

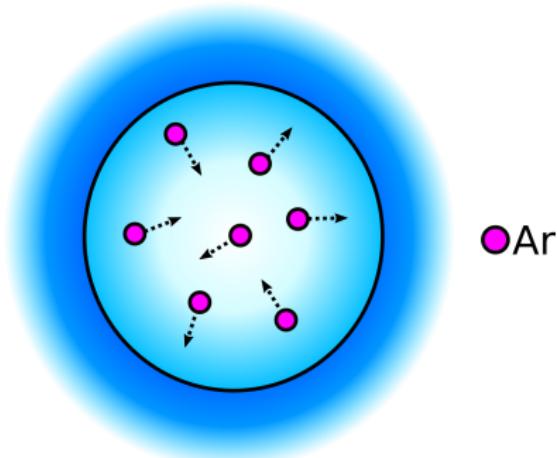
$$u(R_1) = u(R_2) \left( \frac{R_2}{R_1} \right)^2$$



# Argon rectification



# The bubble's interior



$$p_g(t) = \left( p_0 + \frac{2\sigma}{R_0} \right) \left[ \frac{R_0^3 - h^3}{R^3(t) - h^3} \right]^\gamma$$

# The bubble's interior

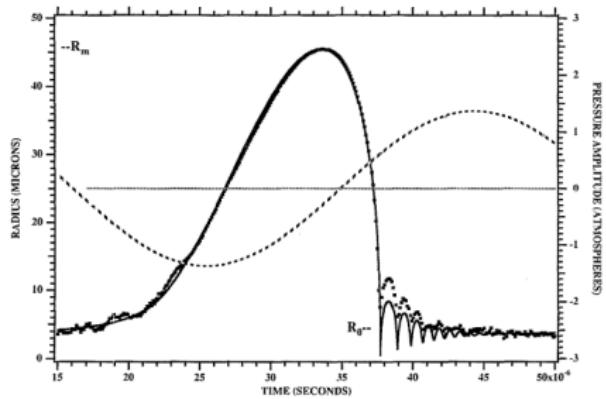


Figure:  $R_0 = 4.5 \mu\text{m}$  and  $T_{max} = 8,500 \text{ K}$ . From Löfstedt, Barber, and Putterman 1993

$$T(t) = T_0 \left( \frac{R_0^3 - h^3}{R^3(t) - h^3} \right)^{\gamma-1}$$

# The bubble's interior: redux

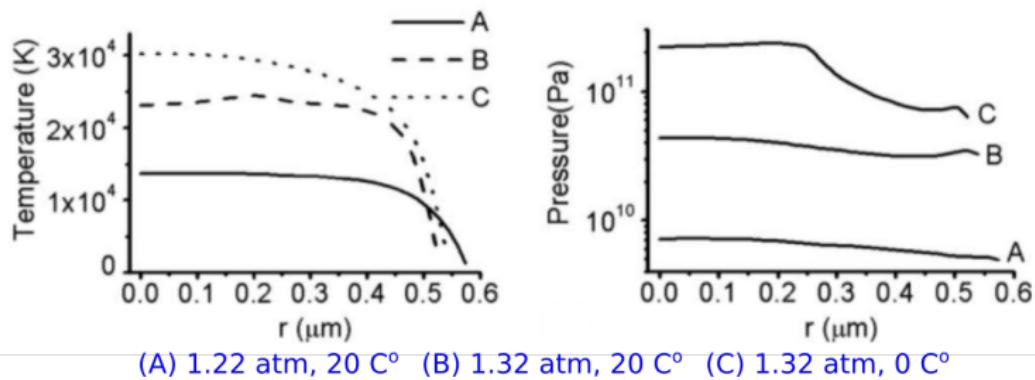
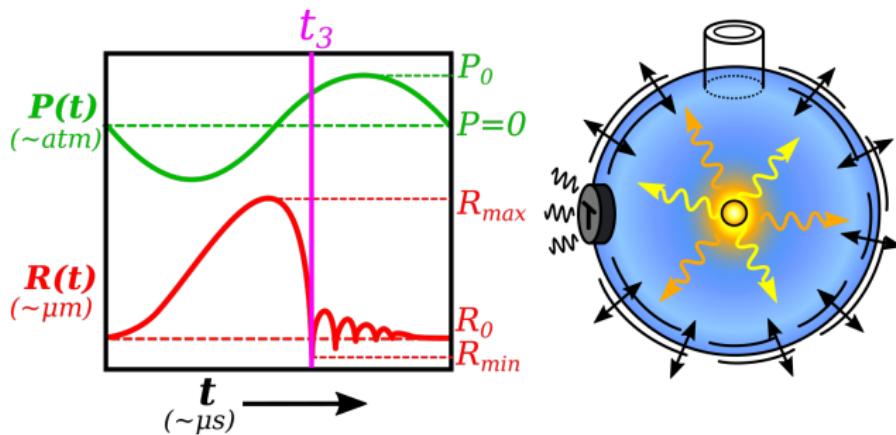
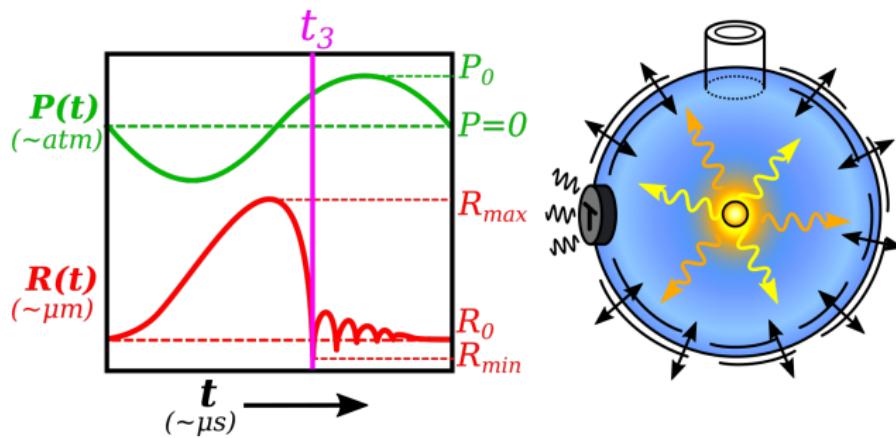


Figure: From An and Li 2009

# Bubble dynamics: sonoluminescence

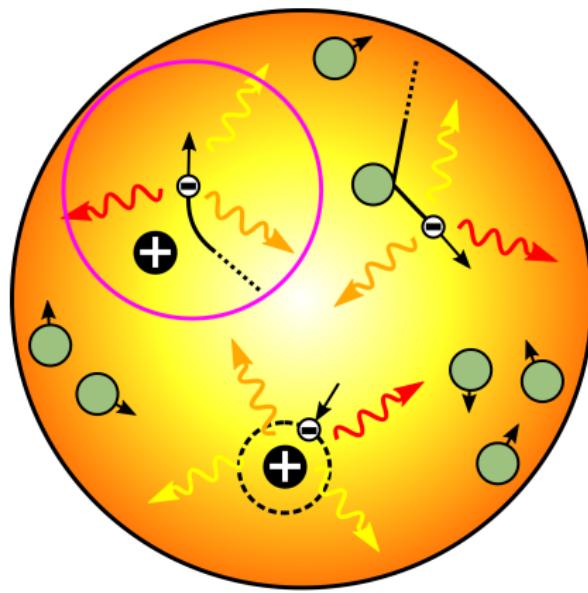


# Volume emission



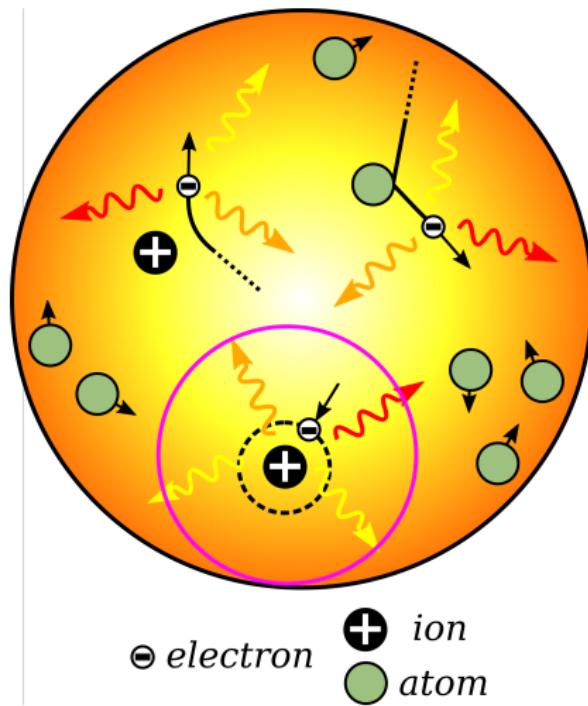
make figure explaining surface vs volume emission and why volume is correct

# Electron-ion bremsstrahlung

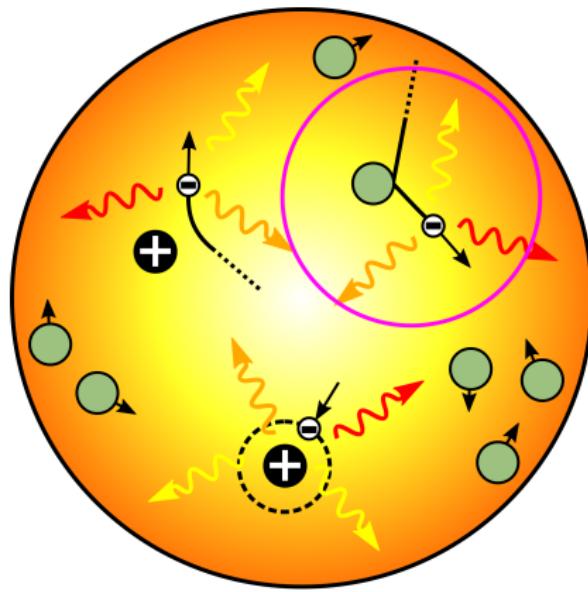


$\ominus$  electron       $+$  ion  
atom

# Electron-ion recombination



# Electron-atom bremsstrahlung



$\ominus$  electron       $+$  ion  
atom

# SBSL in H<sub>2</sub>SO<sub>4</sub>

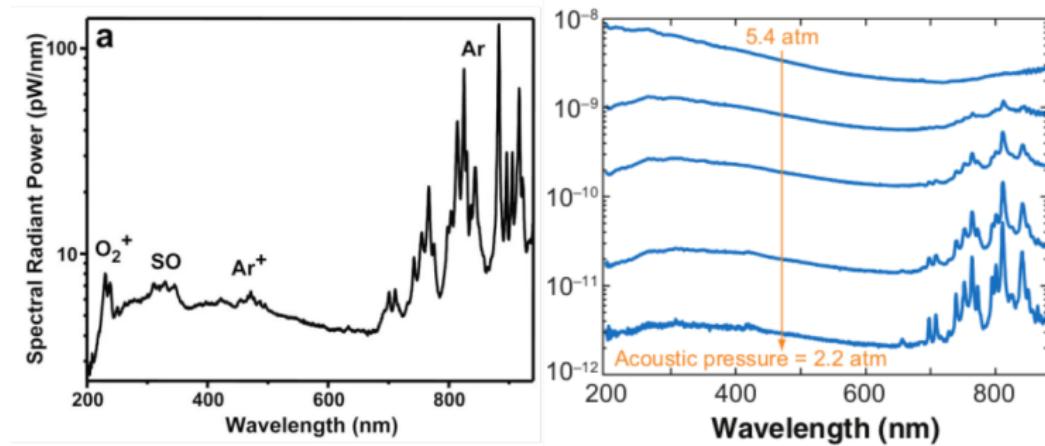


Figure: From Suslick and Flannigan 2008 and Flannigan and Suslick 2005

# Theoretical results

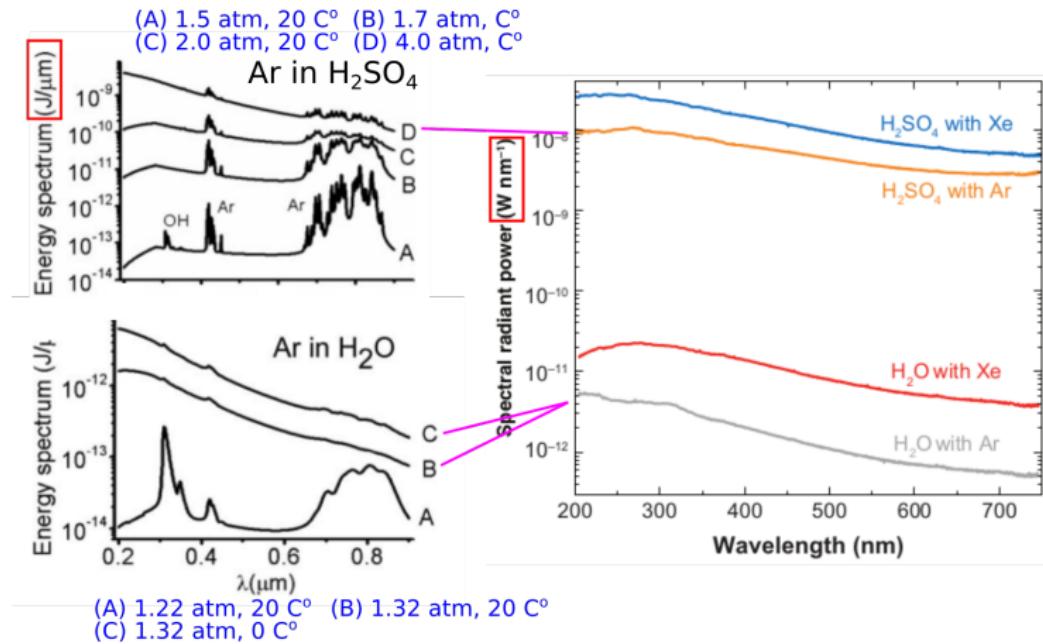


Figure: From An and Li 2009 and Suslick and Flannigan 2008

# Theoretical results

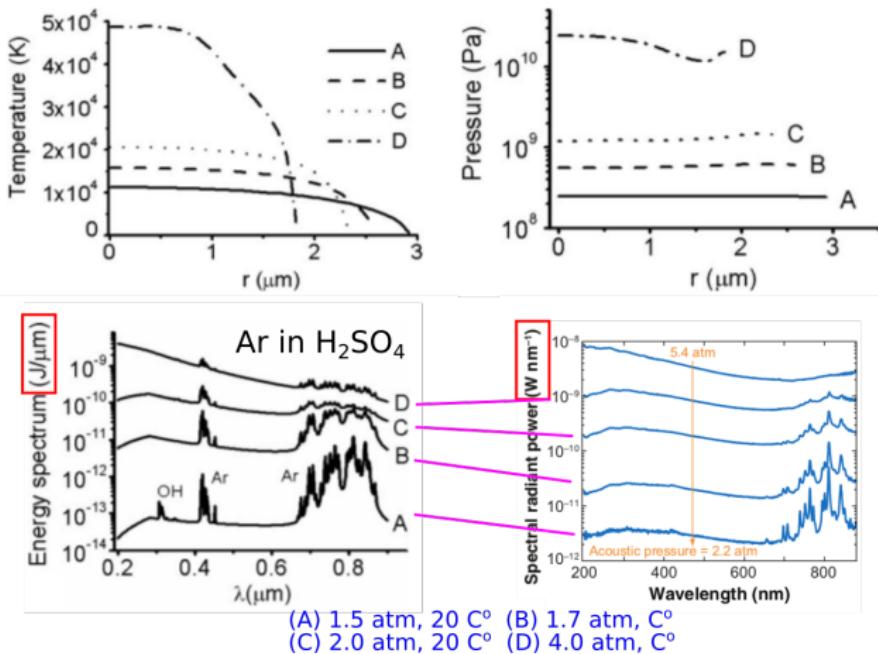


Figure: From An and Li 2009 and Suslick and Flannigan 2008

# Concluding remarks

connect back to shrimp