A FORMATION PROCESS AND GROWTH MODEL FOR SUPERHEATED LIQUID BUBBLE CHAMBERS

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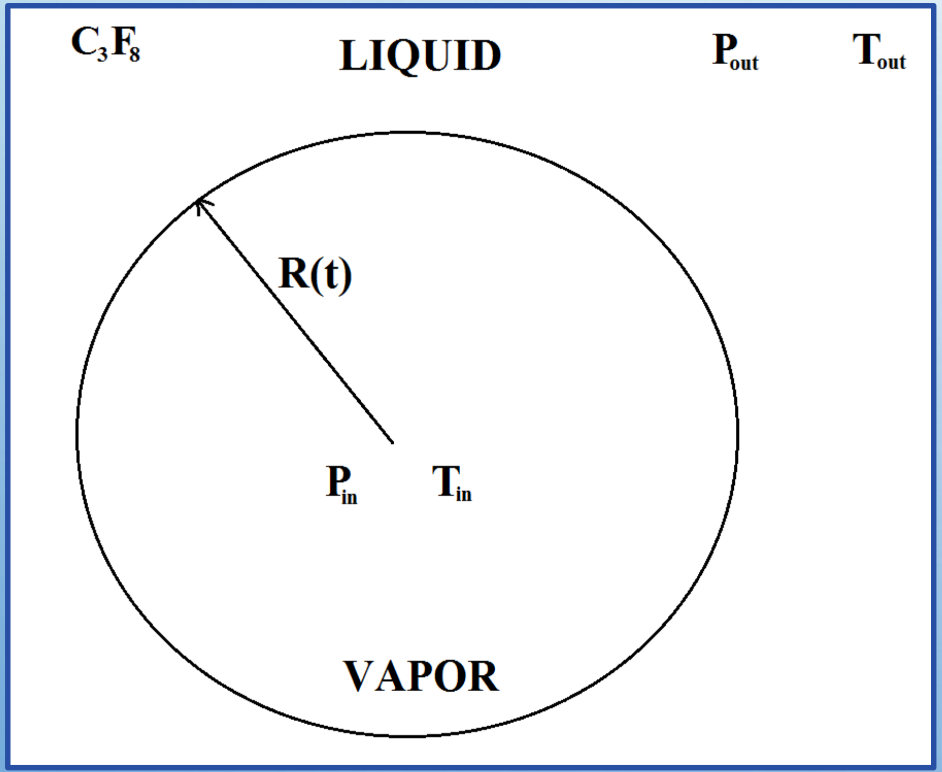
OVERVIEW

- THERMODYNAMICS OF BUBBLE FORMATION
- FLUID DYNAMICS OF BUBBLE GROWTH

BUBBLE FORMATION

- BUBBLES EXIST BECAUSE OF **SURFACE TENSION**



$$R(t=0) = R_{critical}$$

$$R_{critical} = \frac{2\sigma}{P_{in} - P_{out}}$$

$R_{critical}$ and P_{in} are both unknown…

BUBBLE FORMATION

- WITH SIMPLE ASSUMPTIONS P_{in} CAN BE ESTIMATED
  - WE ASSUME **EQUILIBRIUM** TO FIND $R_{critical}$
  - IMPLIES $T_{in} = T_{out}$ AND ISO-CHEMICAL POTENTIAL $\mu_{in} = \mu_{out}$
  - WE ASSUME CONSTANT ISOTHERMAL COMPRESSIBILITY $PV^n = Constant\,; n = 1$

$$P_{in} = P_{sat} exp\left(\frac{-\rho_{in,sat}}{\rho_{out}}\left(\frac{P_{sat} - P_{out}}{P_{sat}}\right)\right) \quad \Rightarrow \quad R_{critical} \text{ can also be estimated}$$

- WITH $R_{critical}$ WE CAN FIND THE VOLUME OF LIQUID THAT NEEDS TO BE EVAPORATED TO FORM THE BUBBLE

$$R = R_{critical}\left(\frac{\rho_{in}}{\rho_{out}}\right)^{\frac{1}{3}}$$

BUBBLE FORMATION

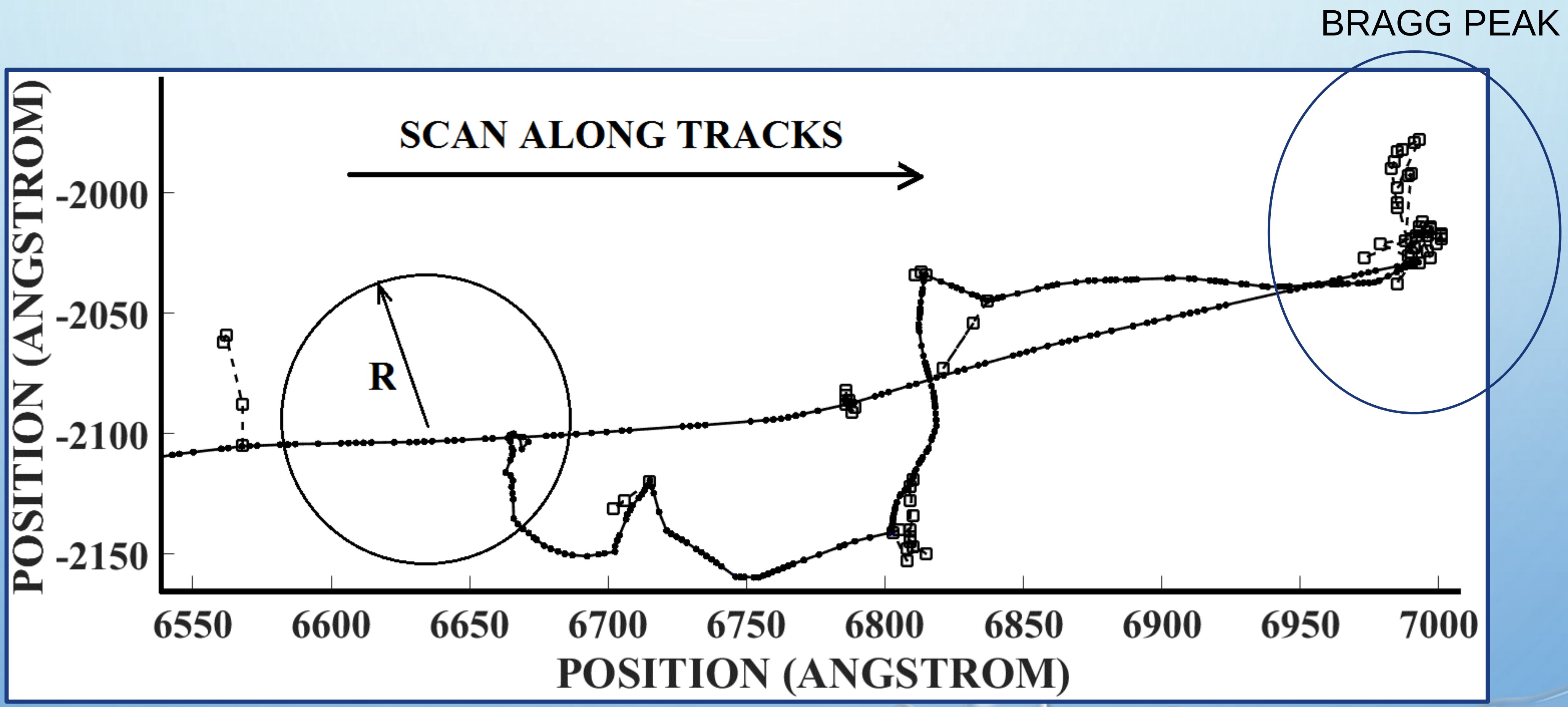
ALPHA

- ELECTRON INTERACTIONS DOMINATE AT HIGH ENERGY
- AT BRAGG PEAK, ELASTIC SCATTERING DOMINATES

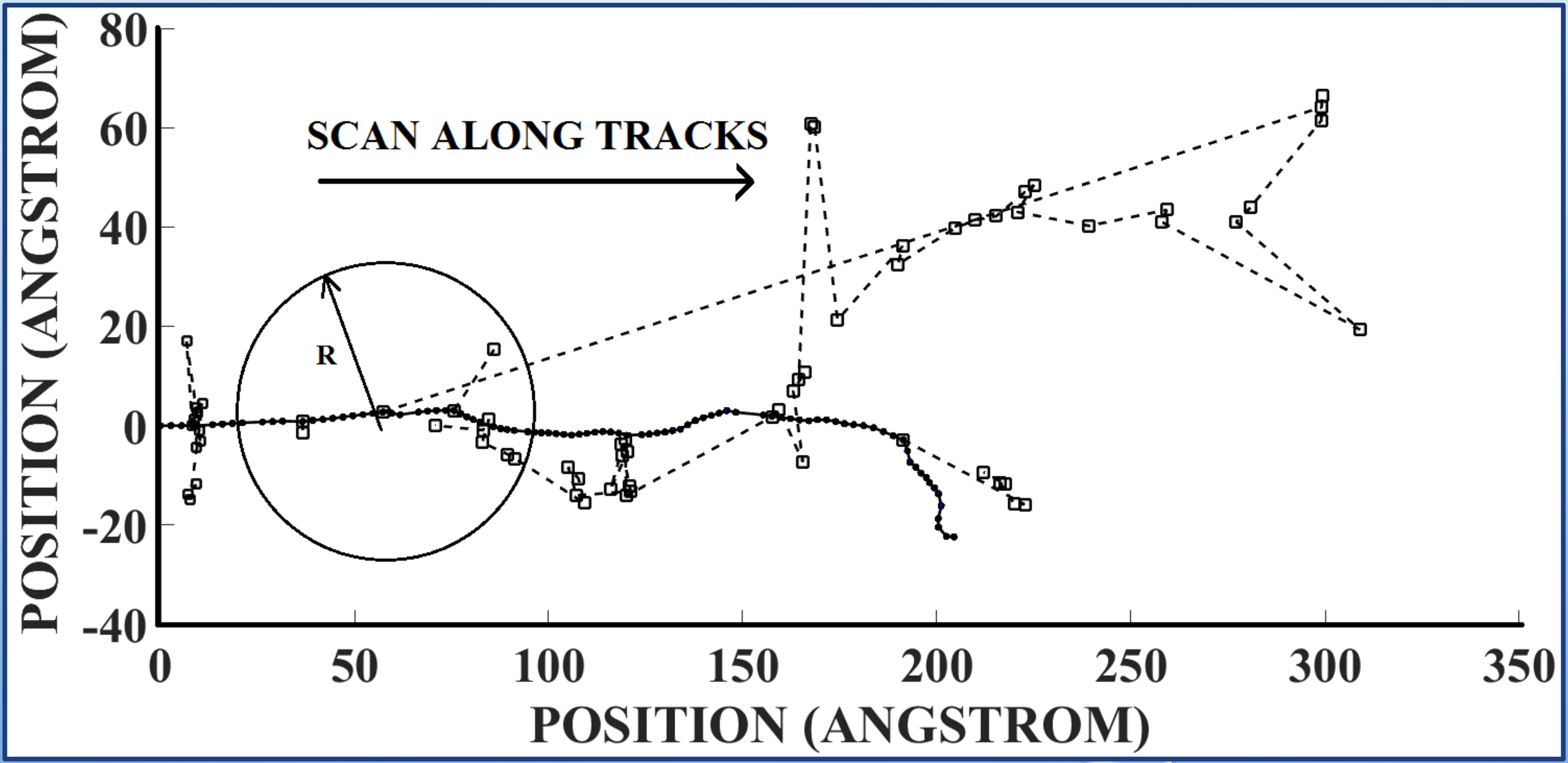
NEUTRON

- DEPOSITS MOST OF ITS ENERGY ON FIRST ELASTIC SCATERING
- CAUSES A CASCADE WHICH DEPOSITS ENERGY SIMILAR TO AN ALPHA

BUBBLE FORMATION



BUBBLE FORMATION



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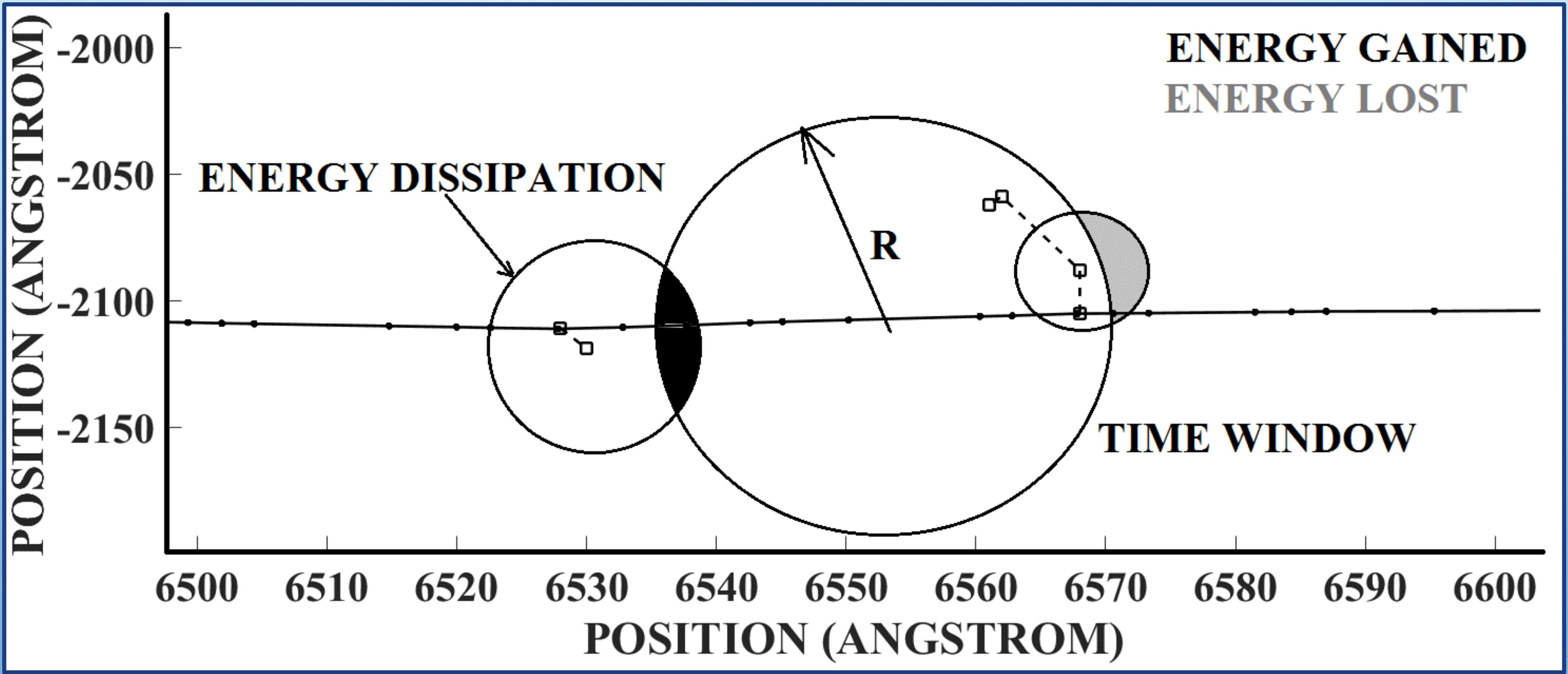


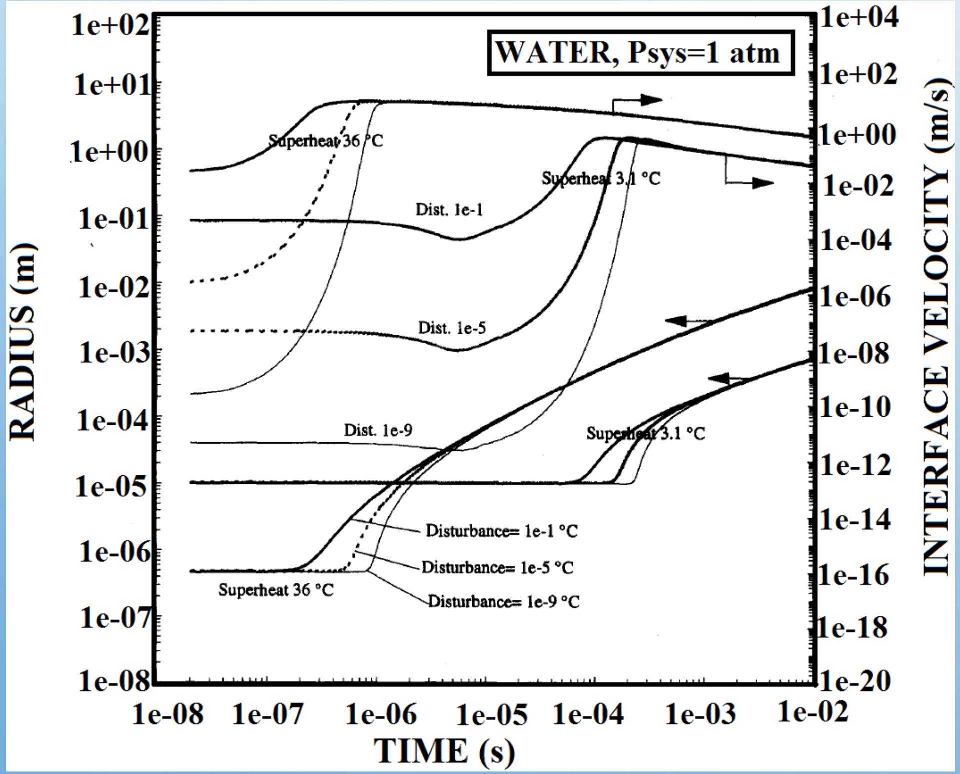
BUBBLE GROWTH

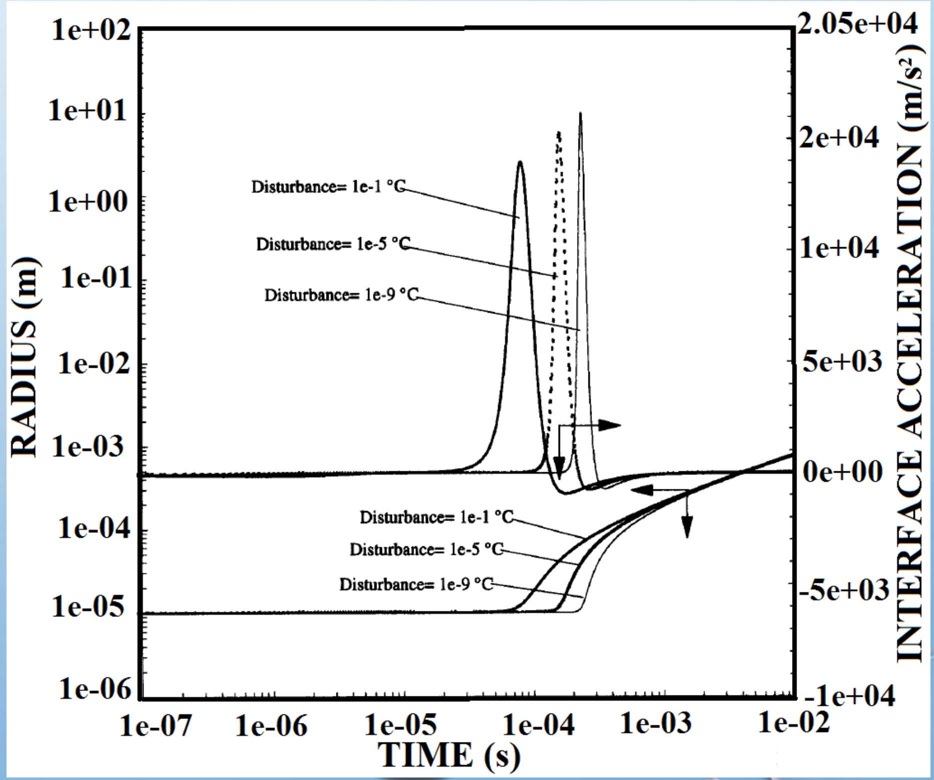
- BUBBLE GROWTH CAN BE SUMMARISED BY TWO COUPLED DIFFERENTIAL EQUATIONS:

1. $R\frac{d^2R}{dt^2}+\frac{3}{2}\left(\frac{dR}{dt}\right)^2=\frac{P_{in}-P_{out}}{\rho_{out}}-\frac{2\sigma}{\rho_{out}R}-\frac{4\mu}{\rho_{out}R}\frac{dR}{dt}$; MOMENTUM EQUATION
2. $\frac{\partial T}{\partial t}+\frac{R^2}{r^2}\frac{dR}{dt}\nabla_s T=\alpha\nabla_s^2 T$; ENERGY EQUATION
3. $4\pi R^2 k_l\left(\frac{\partial T}{\partial r}\right)\Big|_{r=R}=h_{vap}\frac{d}{dt}\left(\frac{4}{3}\pi R^3\rho_v\right)$; BOUNDARY CONDITION

BUBBLE GROWTH

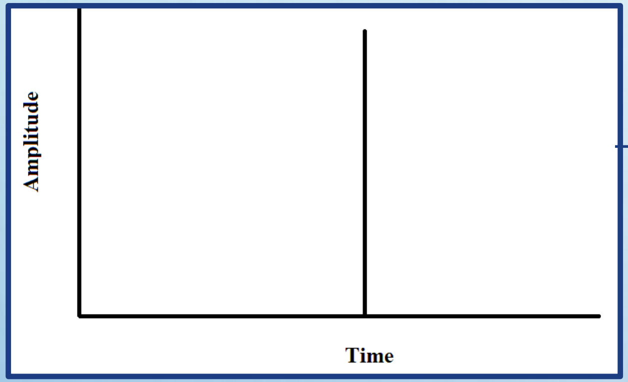
- WE WANT R, $\frac{dR}{dt}$ AND $\frac{d^2R}{dt^2}$; THE EXPECTED SOLUTION SHOULD BE SIMILAR TO:



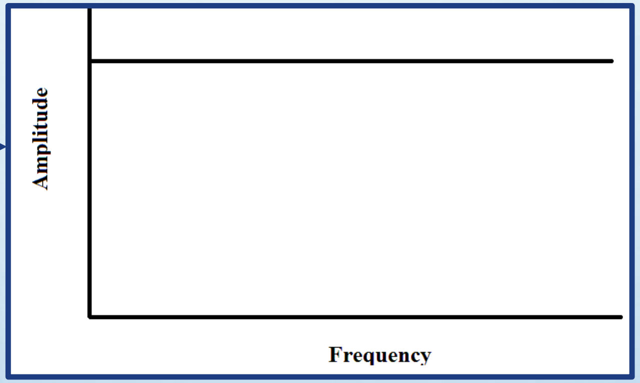


BUBBLE GROWTH

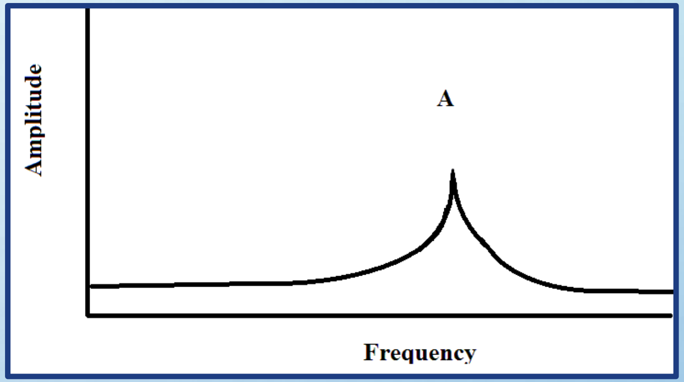
PERFECT STRIKE



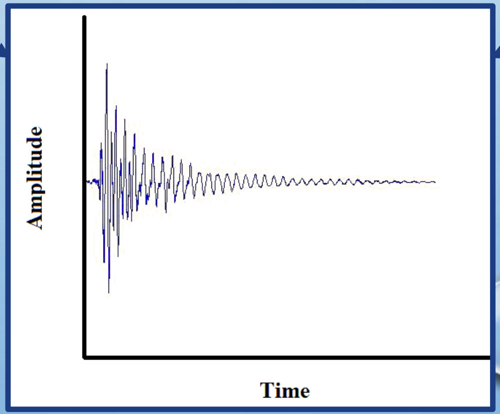
FFT



GUITAR CORD FREQUENCY RESPONSE



TOGETHER



<u>**ACOUSTIC SIGNAL**</u>

BUBBLE GROWTH

- THE INTERFACE ACCELERATION IS SIMILAR TO THE ACTION OF STRIKING
- THE ACRYLIC WALL, THE PIEZO HOUSING AND THE PIEZO CERAMIC ALL HAVE DIFFERENT FREQUENCY RESPONSES
- BY WORKING BACKWARDS WE CAN EXTRACT THE “STRIKE” THAT GENERATED THE ACOUSTIC SIGNAL ALL THE WAY BACK TO THE CAUSE OF THE BUBBLE, EITHER A NEUTRON OR AN ALPHA