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跨 領 域 專 題 演 講

A Functional Ultrasound Image Based on a Generalized Rayleigh Distribution

Yu-Chen Shu

Cooperators: Po-Hsiang Tsui, Chien-Cheng Chang,
Ming-Chih Ho, Wen-Shiang Chen,
Chiung-Nien Chen, King-Jen Chang

前言



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Google 瀏覽器 Chrome 圖示



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Chrome 圖示的由來



<http://ten-posterous.posterous.com/chrome-424>



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Chrome 圖示的由來



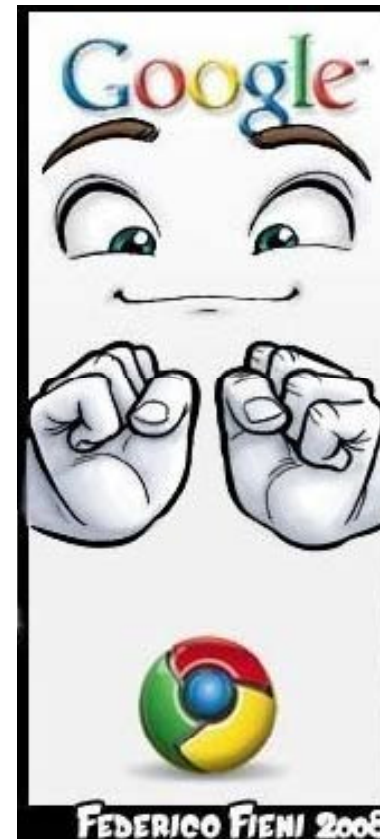
<http://ten-posterous.posterous.com/chrome-424>



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Chrome 圖示的由來



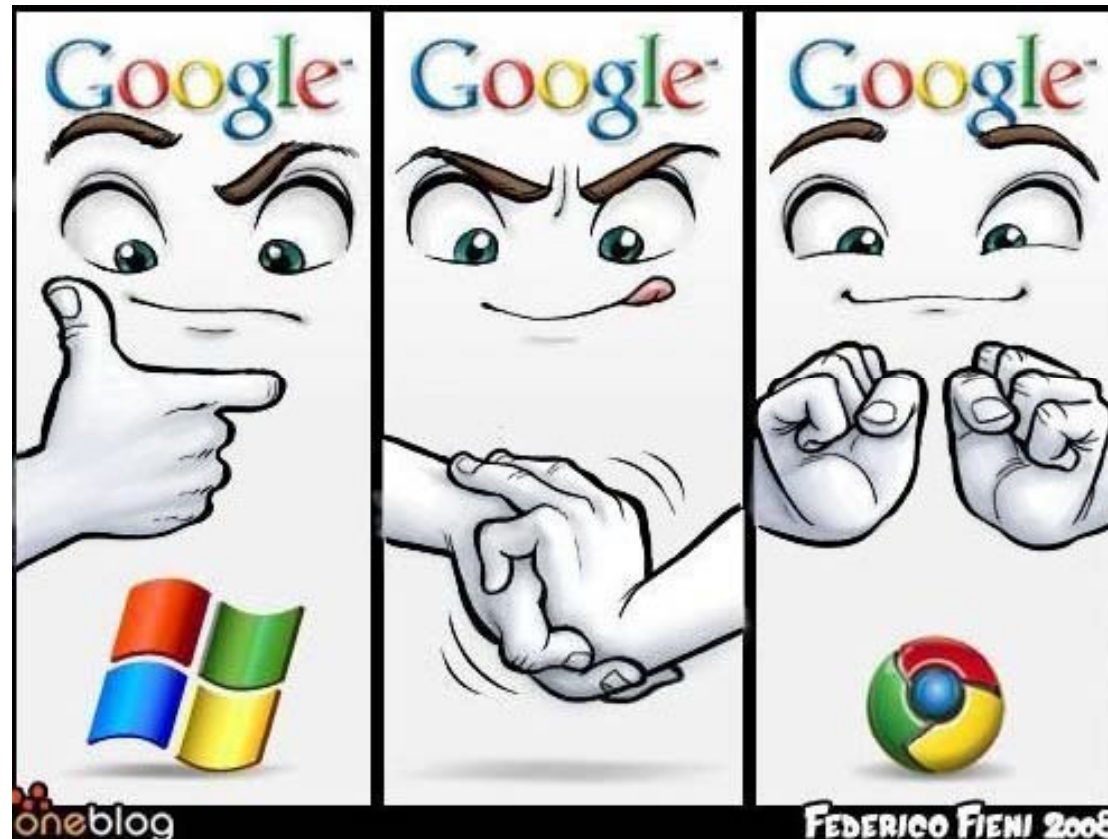
<http://ten-posterous.posterous.com/chrome-424>



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跨領域的研究



<http://ten-posterous.posterous.com/chrome-424>

跨領域醫學



跨領域數學

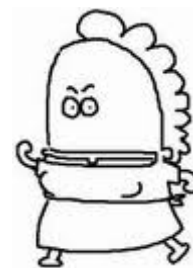


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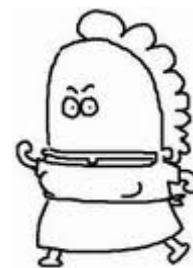
跨領域數學

數學為科學之母

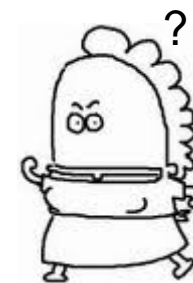


跨領域數學

數學為科學之母



母親像月亮一樣



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跨領域數學



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跨領域...數學？



數學 = 夢靨



<http://t17.techbang.com.tw/topics/8289-you-see-a-thing-seediq-bale>

跨領域數學



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國立成功大學八十週年

Outline

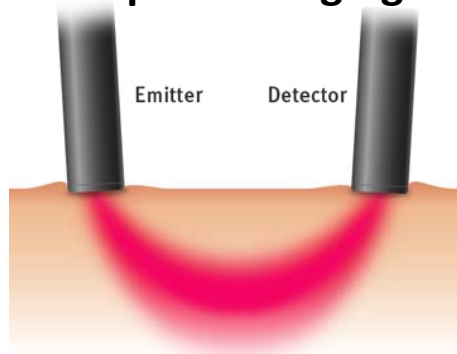
- Introduction of Ultrasound Image
- Image Based on a Generalized Rayleigh Distribution
- Applications
- Concluding Remarks

Introduction of Ultrasound Image

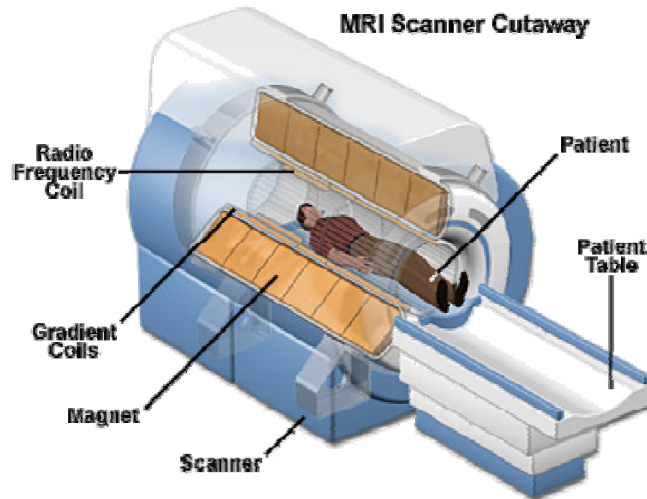
- Medical Imaging
- Advantages and disadvantages
- How to create an ultrasound image

Medical Imaging

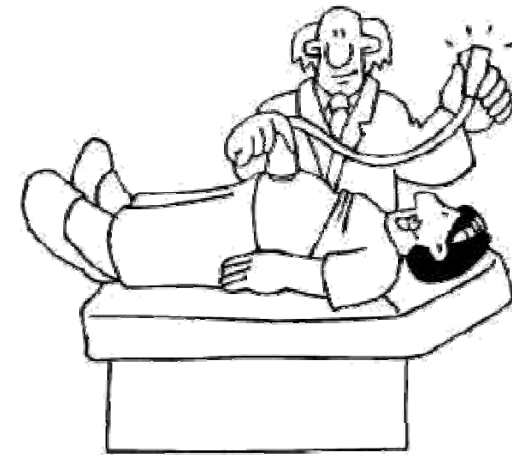
Optical imaging



X-ray imaging



MRI imaging



Ultrasound image

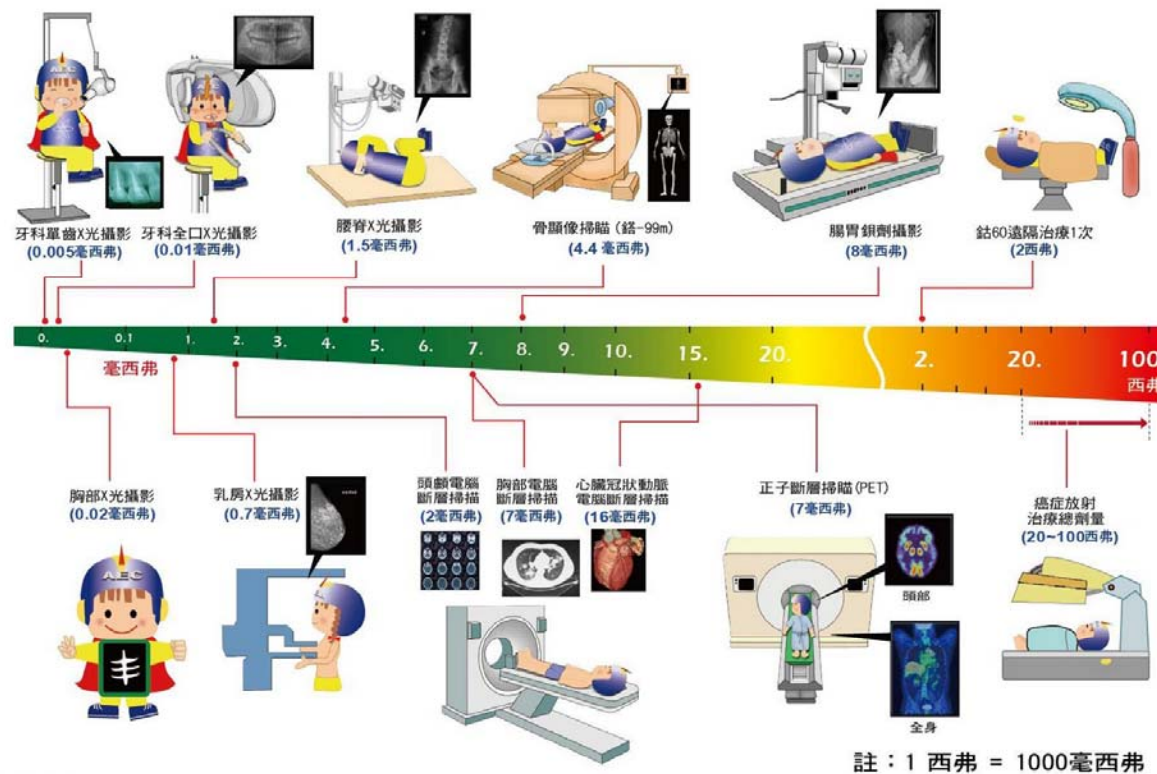


X-Ray Imaging



Radiation of X-Ray imaging

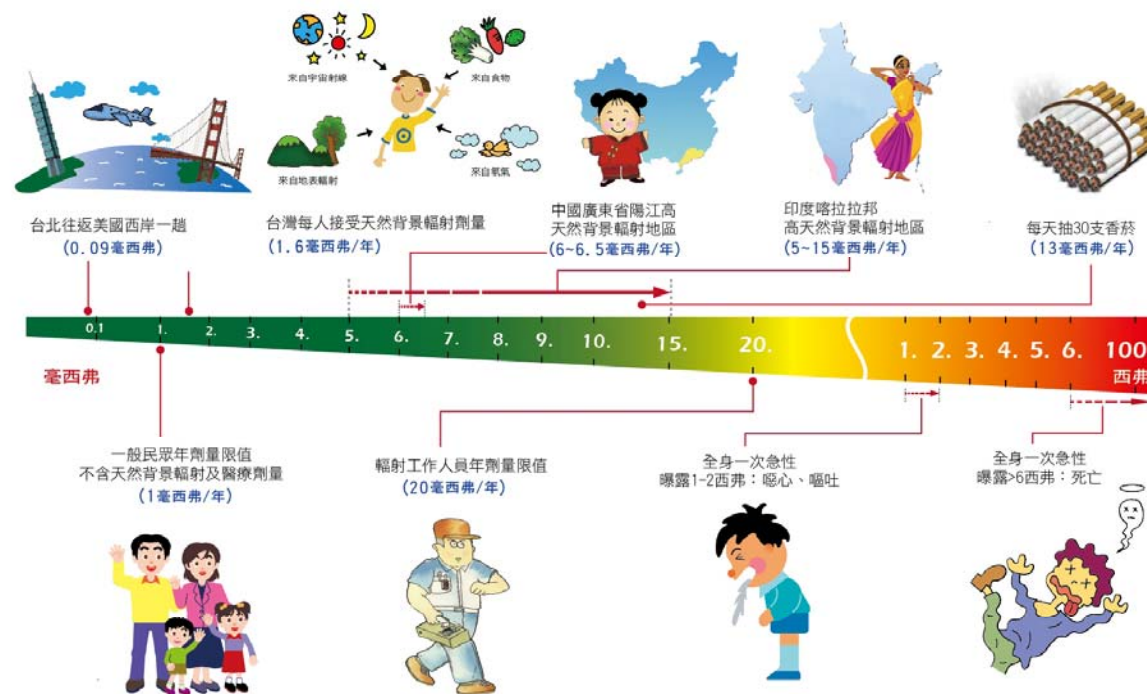
醫療游離輻射劑量比較圖



行政院原子能委員會 製作

The effects of Radiation

一般游離輻射劑量比較圖



行政院原子能委員會 製作

註：1 西弗 = 1000毫西弗

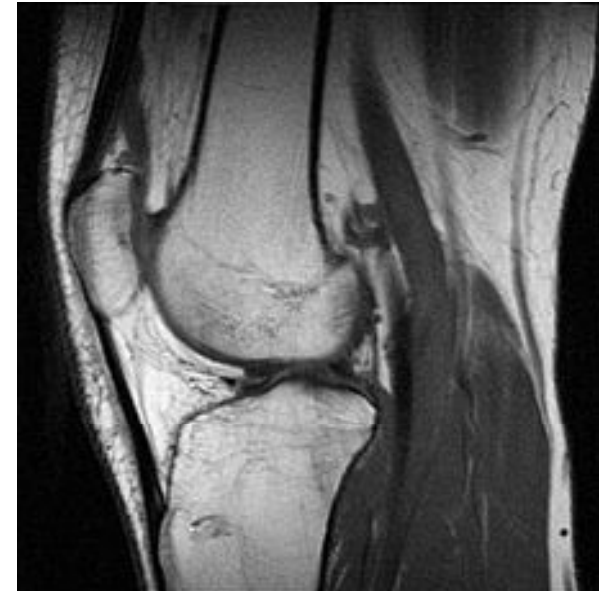
Trade-off of X-Ray imaging

- Relatively low-cost investigation with a high diagnostic
 - Chest X-Ray, bony fractures, bony pathology, foreign objects, dental radiography, Computed tomography (CT)

MRI imaging

● Advantage

- non-ionizing radiation
- Best suited for soft tissue
- For brain, MRI is superior



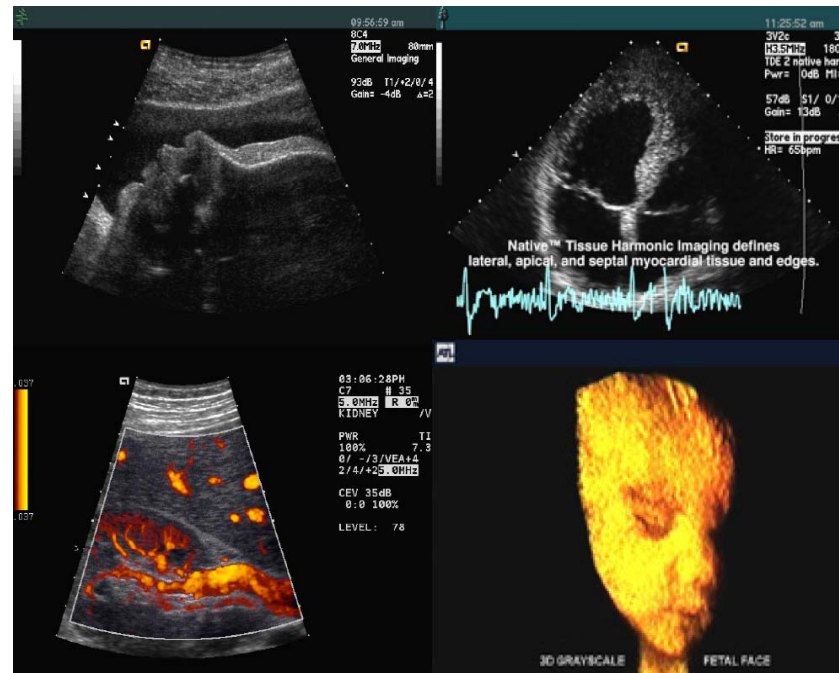
● Disadvantage:

- Expensive
- Not portable
- Suffers from motion artifacts



Advantages of ultrasound imaging

- Noninvasive
- Soft tissues
- Real time
- Portable
- Non-ionizing
- Good resolution

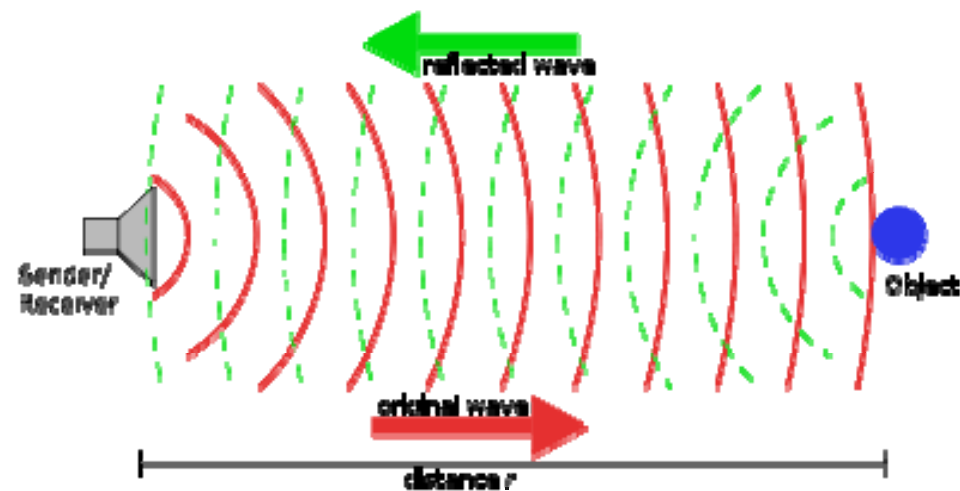


Weaknesses of ultrasound imaging

- Penetrating bone: transcranial ultrasonography
- Gas: lung imaging is not possible
- Depth may be limited for obese patients
- Operator-dependent
- The location is determined under the assumption that sound speed is fixed.

Create an ultrasound image

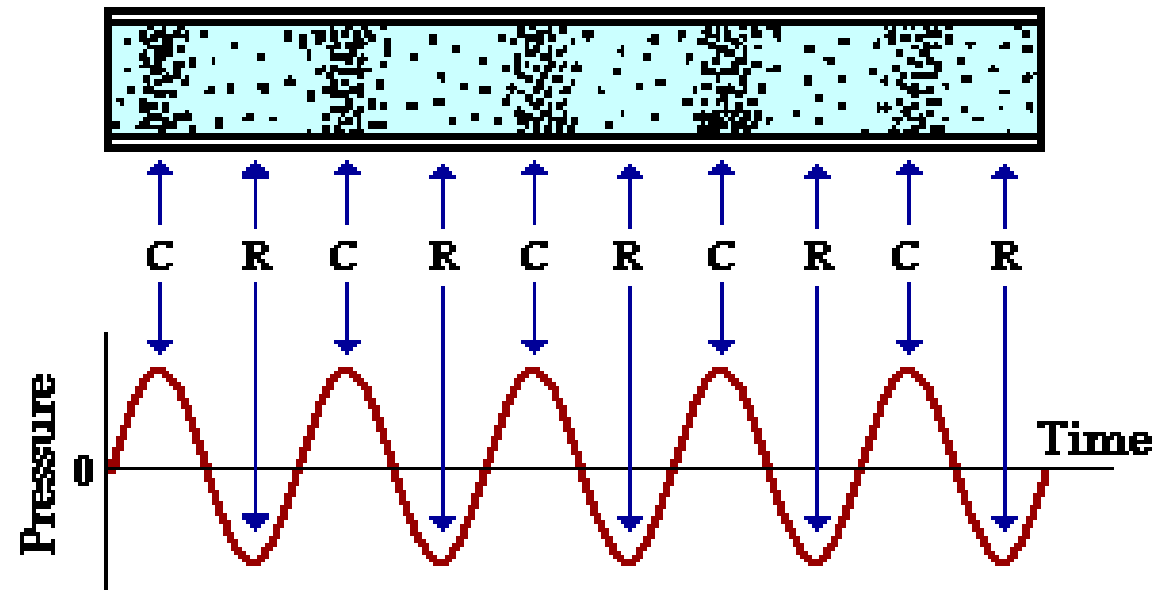
- Producing a sound wave
- Receiving echoes
- Interpreting those echoes



Sound wave



Sound is a Pressure Wave



NOTE: "C" stands for compression and "R" stands for rarefaction

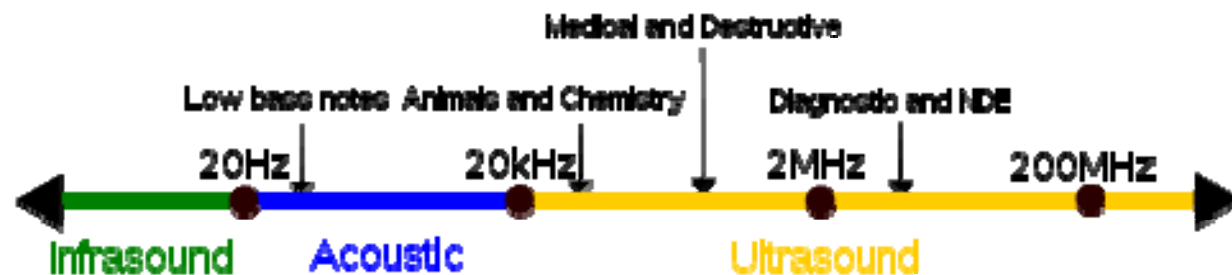


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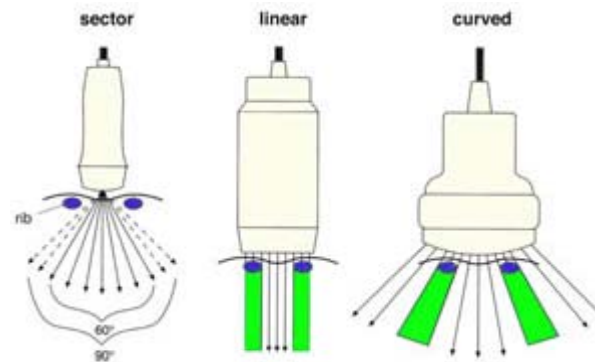


Ultrasound

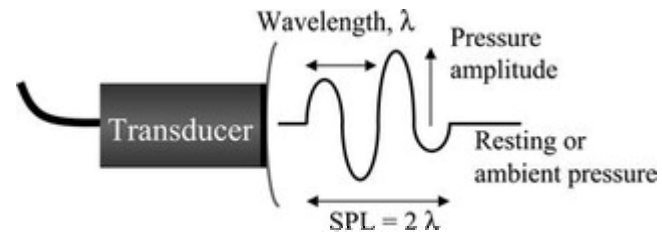
- Acoustic waves with frequencies higher than 20 kHz
- Need a medium to propagate
- Longitudinal wave
- Non-ionizing radiation



Producing a sound wave

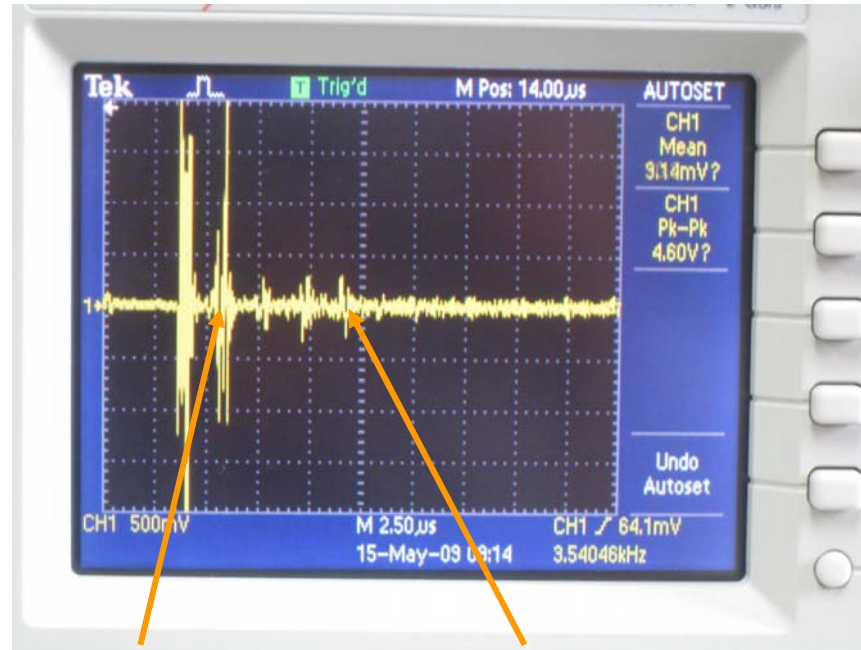
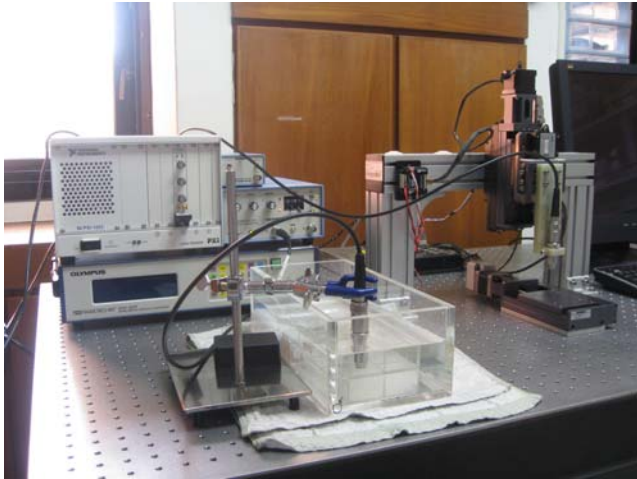


Ultrasound transducer



<http://www.wikiradiography.com/page/Ultrasound+Physics>

Receiving echoes



Reflection signal

Scattering signal

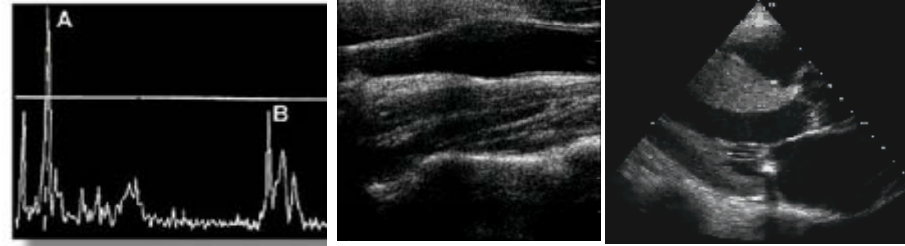


Receiving echoes

- Pre-amplification
- Depth (Time) Gain Compensation
- Compression
- Demodulation
- Other signal processing

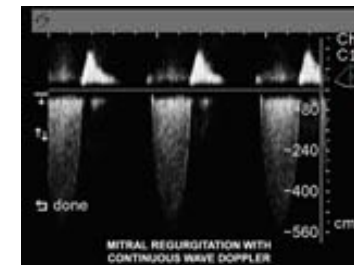
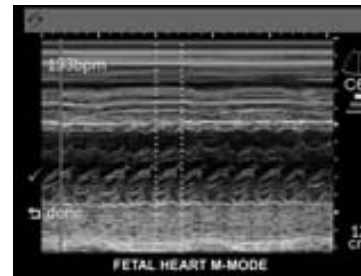
Interpreting the echoes

● A-mode: Amplitude

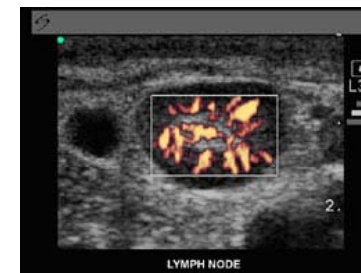
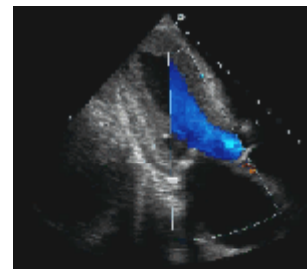


● B-mode: Brightness

● M-mode: Motion



● D-mode: Doppler



● E-mode: Energy

<http://www.frca.co.uk/article.aspx?articleid=300>

What can a mathematician do?

- For example, Reducing noise or speckle
 - It may not be useful for an experienced doctor.
- Can we give more information from those echoes?
- Is it meaningful?
- How do we use them to help patients?



A VERY LONG WAY

雖千萬人，吾往矣



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總有一天...



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跨 領 域 專 題 演 講

Image based on a generalized
Rayleigh distribution

Lord Rayleigh, 1842-1919

- Discovered the element: argon
 - Nobel Prize for Physics in 1904
- Discovered the phenomenon: Rayleigh scattering
- Predicted the existence of the surface waves:
Rayleigh waves



*John William Strutt
Rayleigh*

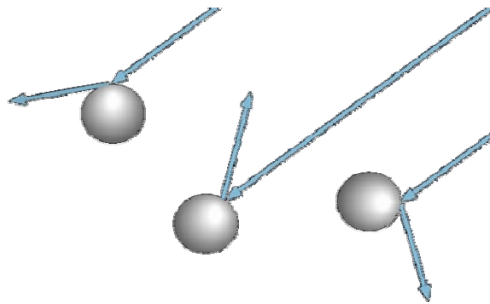
http://en.wikipedia.org/wiki/John_William_Strutt,_3rd_Baron_Rayleigh



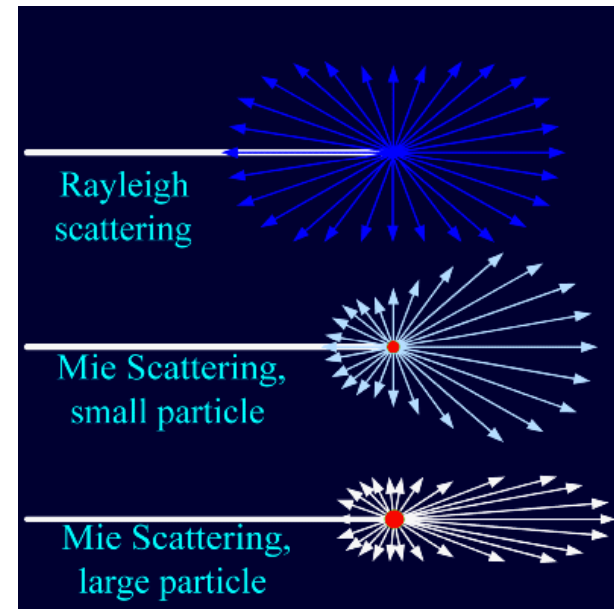
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Scattering



- Size of particles (S)
- wave length (λ)
- $S \ll \lambda$: Rayleigh scattering
- $S \sim \lambda$: Mie scattering
- $S \gg \lambda$: Geometric optics (scattering)



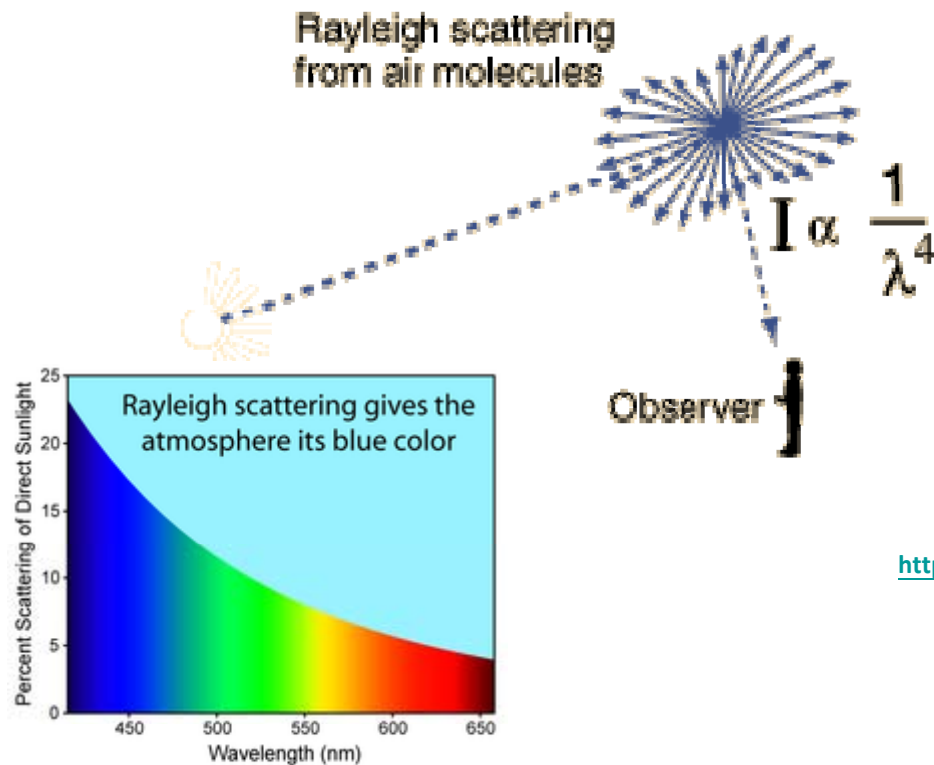
Blue Sky, white cloud, and red sunset



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Why? Rayleigh scattering



The strong wavelength dependence of Rayleigh scattering enhances the short wavelengths, giving us the blue sky.

The scattering at 400 nm is 9.4 times as great as that at 700 nm for equal incident intensity.

<http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/blusky.html>

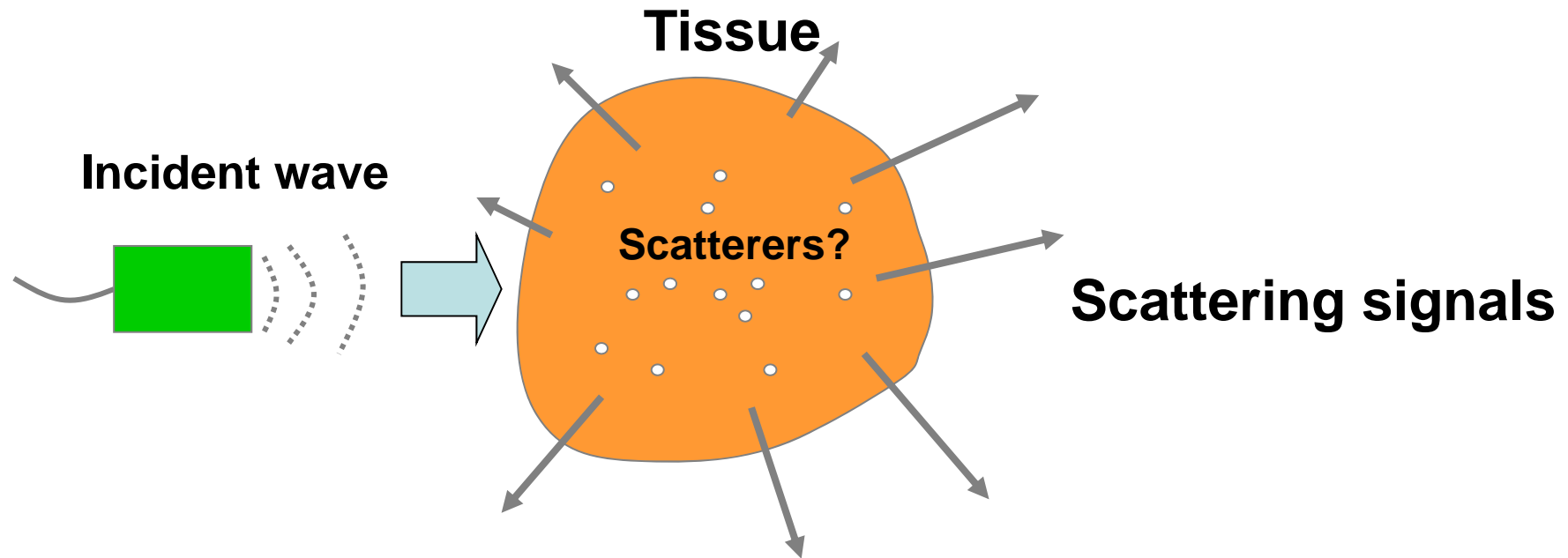
http://en.wikipedia.org/wiki/Rayleigh_scattering



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Scattering properties in tissues?



Scattering behavior should depend on scatterer structures