

The background is a vibrant, abstract composition. It features several large, organic shapes in shades of red, orange, and teal. These shapes are filled with various patterns: some are solid, some have a fine dot pattern, and others have wavy white lines. The background also includes a white area with a black dot pattern and a grey area with a white plus sign pattern. Small, black, wavy lines are scattered throughout the composition, resembling sound waves or stylized text.

言语科学

—
声音的处理

吴民华



声音的处理

声音的放大

数字化

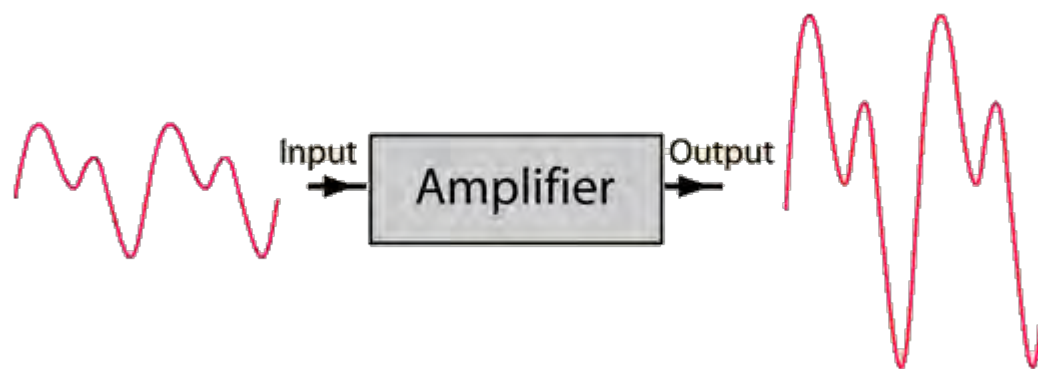
采样

量化

滤波

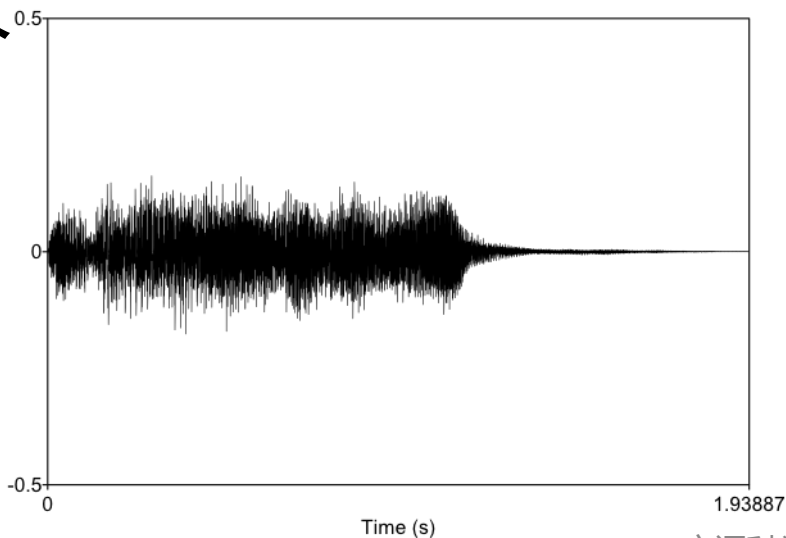
共振

声音的放大

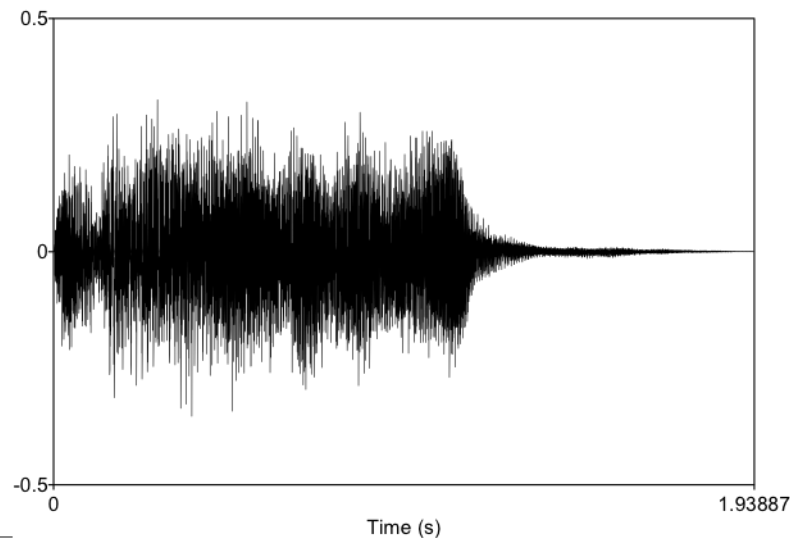


声音的放大

- 可以简单的把振幅放大
- 也可以只针对某些频率而放大，而放大的倍数也可以不一样
- 加权



言语科学 - 声音的处理



声音的数字化 digitization

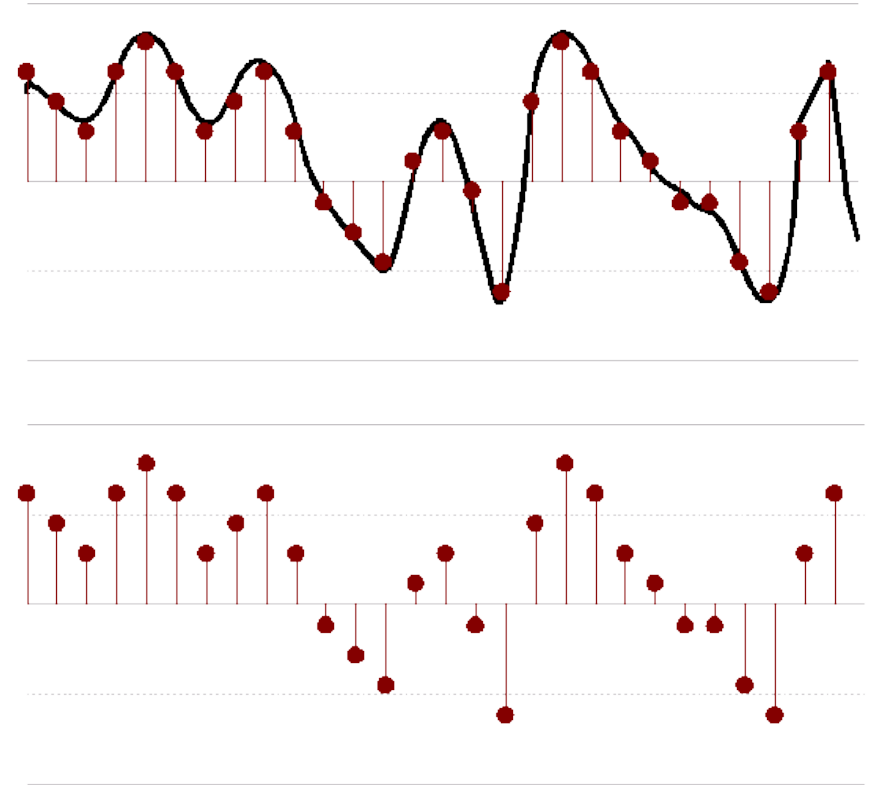
- 所有信号分为连续模拟信号 (analog signals) 和数字信号 (digital signals)
- 把模拟信号转为数字信号的过程称为数字化
- 为什么要数字化?
- 包括采样 (sampling) 和量化 (quantization) 两步骤

模拟 vs 数字



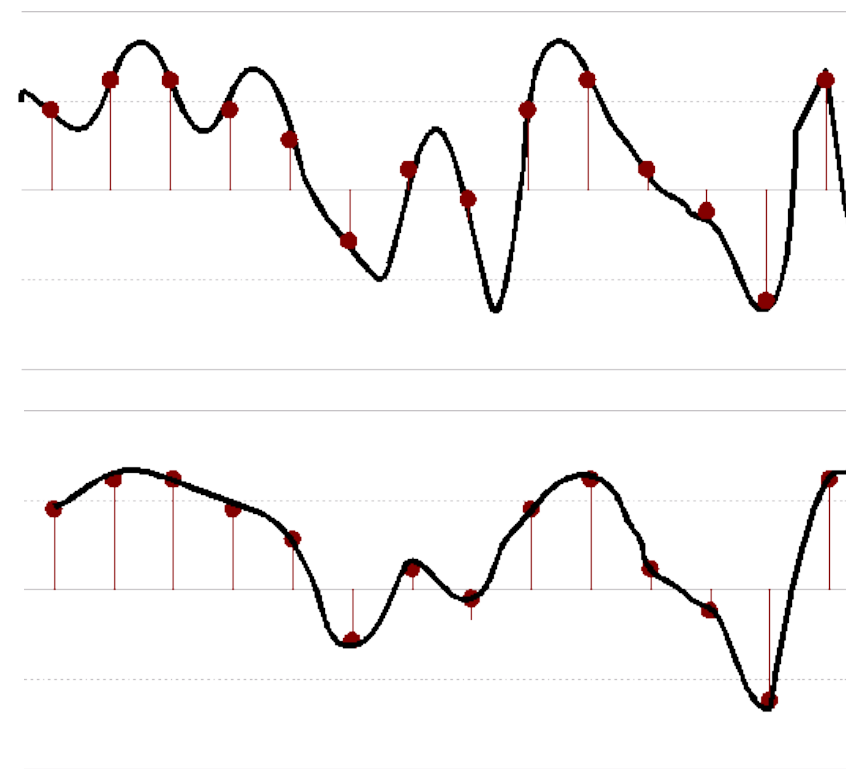
采样

- 从模拟（连续）信号中选取点的过程
- 其速度称为采样率（sampling rate）或者采样频率（sampling frequency）[Hz]
- 每秒钟采多少



欠采样 undersampling

- 当采样速度太低时，最终形成失真 distortion



什么采样率最好？

- 采样=调制 (modulation) , A/D转换
- 采样过快：数据过多 (过采样) ; 采样过慢：丢失信息 (欠采样)
- 奈奎斯特 (Nyquist) 理论：采样频率必须至少是所需保留最高频率的两倍
- 例如：要保留最高频率为20 kHz的信息，至少需要以40 kHz的采样频率进行采样
- 例如：CD、DVD音乐：采样频率为44.1 kHz

采样的演示

- 比较44.1 kHz, 22.05 kHz, 和11.025 kHz 的采样率

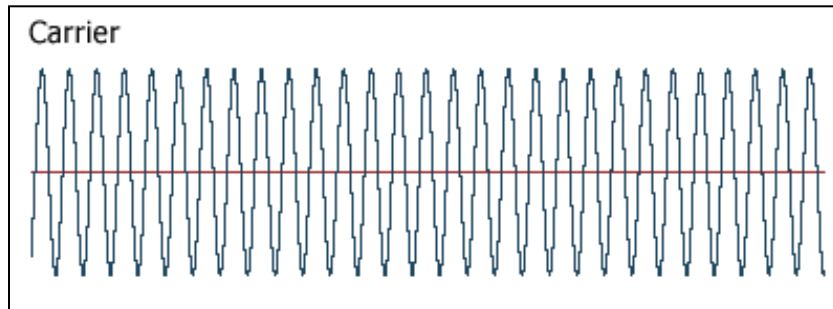


量化

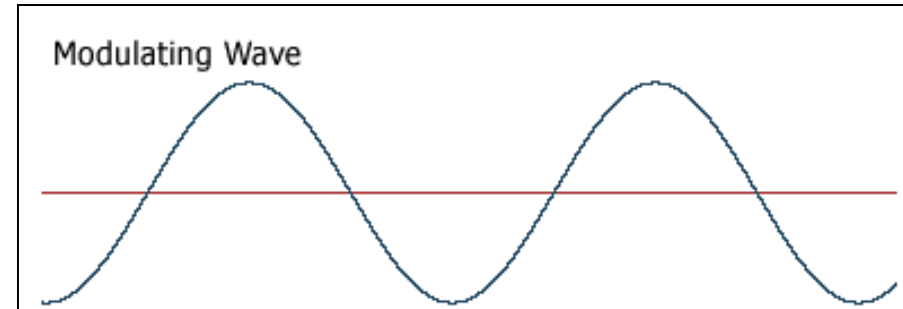
- 指每个数据点要使用多少存储空间？需要多少位？
- 16位/采样点 (16 bits/sample) = 使用一个16位的二进制数来存储电平（振幅）的值
- 16位元可以表示 $-32,768 \sim +32,767$ 个不同的电平据称
- 16位/采样点量化表示的动态范围足以表示所有音乐中存在的整个动态范围也称为“位深度” (bit depth)

Bits	Possible integer values	Range of levels represented
4	16	-8 ~ +7
8	256	-128 ~ +127
11	2048	-1024 ~ +1023
12	4096	-2048 ~ +2047
16	65,536	-32,768 ~ +32,767
18	262,144	-131,072 ~ +131,071
20	1,048,576	-524,288 ~ +524,287
24	16,777,216	-8,388,608 ~ +8,388,607
32	4,294,967,296	-2,147,483,648 ~ +2,147,483,647
48	281,474,976,710,656	-140,737,488,355,328 ~ +140,737,488,355,327
64	18,446,744,073,709,511,616	-9,223,372,036,854,775,808 ~ +9,223,372,036,854,775,807

调幅 Amplitude Modulation (AM)

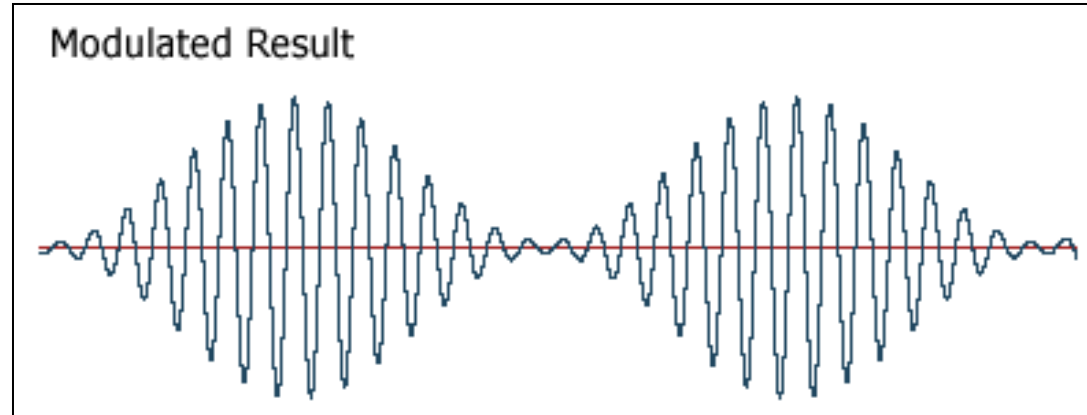


Carrier wave



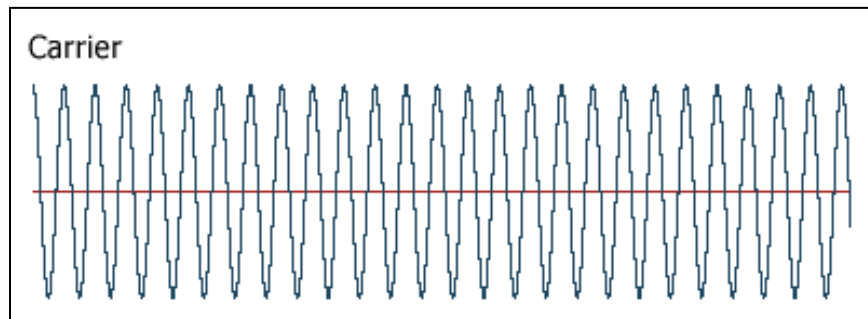
Modulating wave

调幅 Amplitude Modulation (AM)

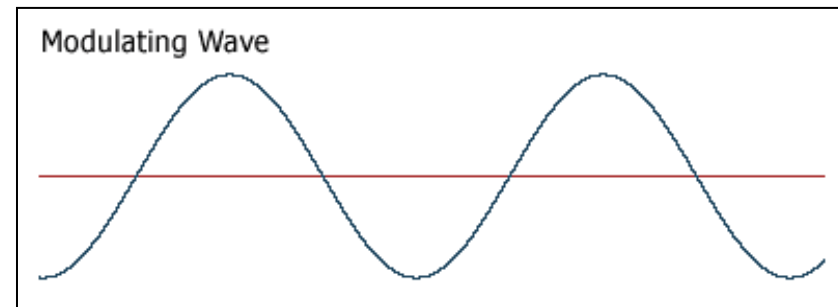


AM signal

调频 Frequency Modulation (FM)

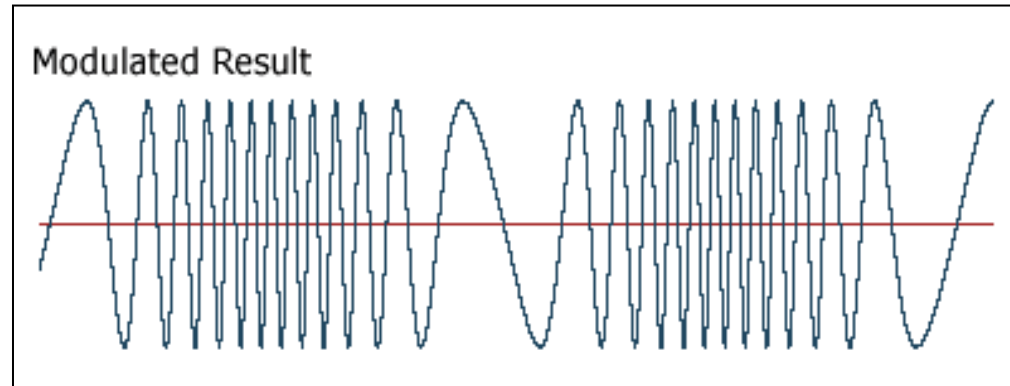


Carrier wave



Modulating wave

调频 Frequency Modulation (FM)



FM signal

调幅 vs 调频

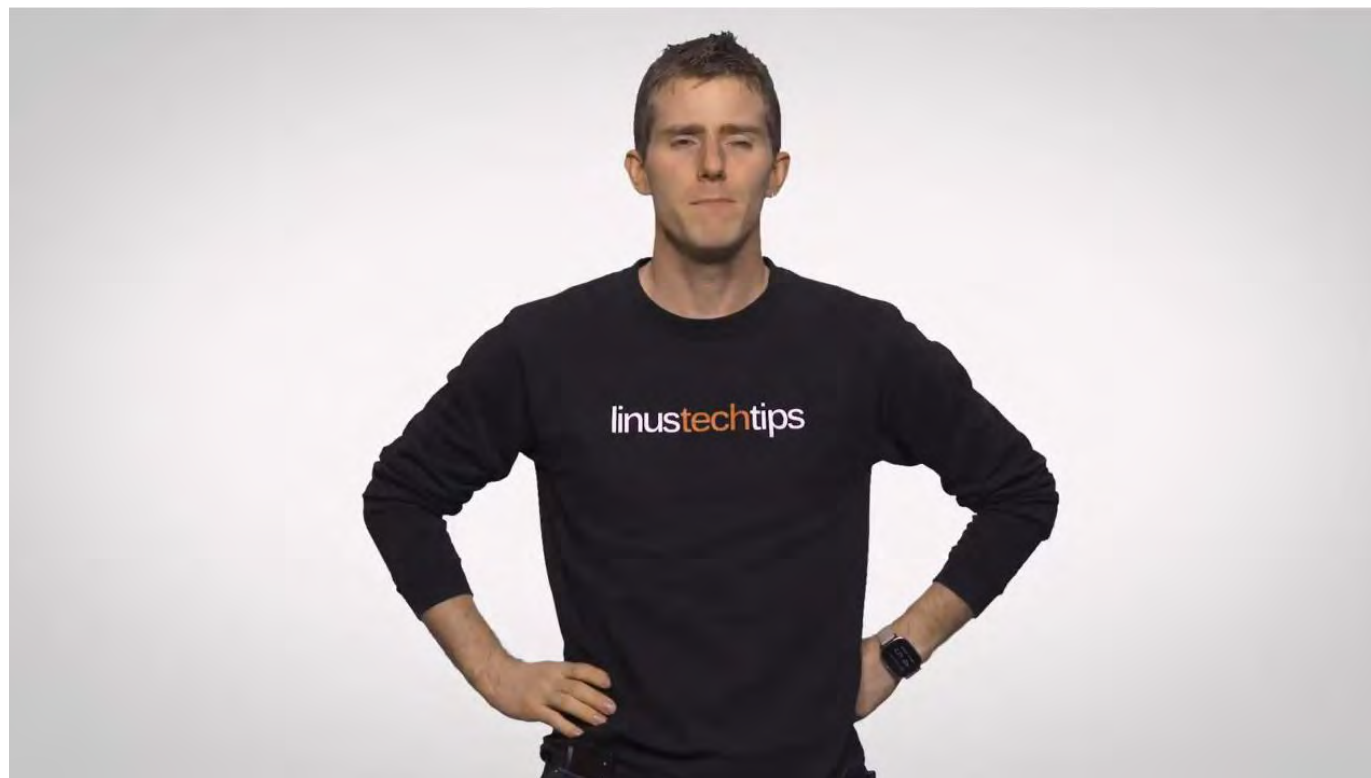
FM

- 仅能在短距离内传播；覆盖范围小
- 保持高质量、高保真度
- 适用于质量良好的广播，如音乐电台频道

AM

- 能传输较远的距离，覆盖范围较大
- 质量较差，保真度较低
- 适合于信息类广播，例如天气、新闻、体育广播频道

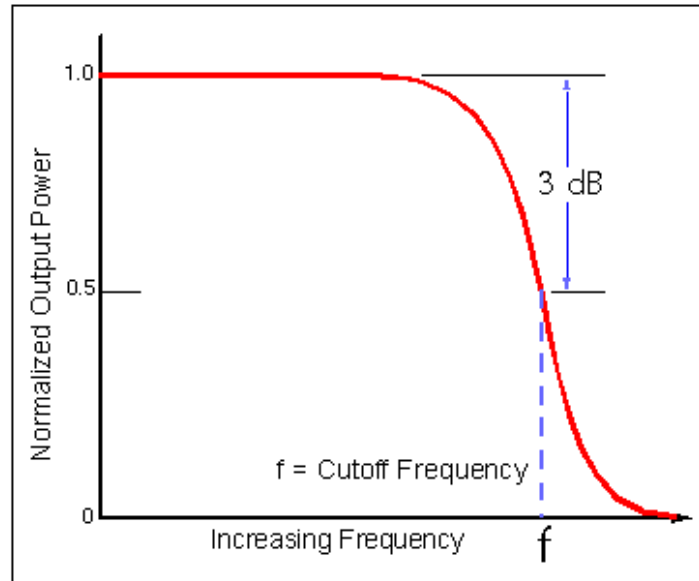
收音机信号传播的制式



滤波 Filtering

- 滤波器是一个可以筛选某些频率予以阻挡，而其他频率则可通过的过程
- 类似于一个筛选器一样
- 可以是一个实体装置、电路或软体程序可分为低通 (low pass)、高通 (high pass)、带通 (band pass)、带阻 (band stop)

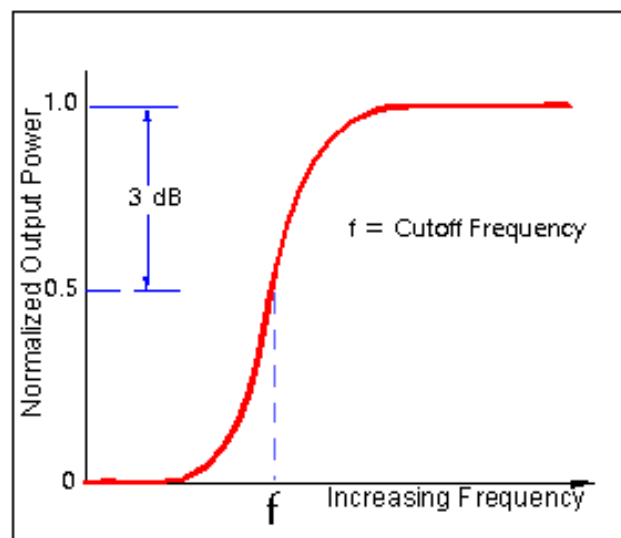
低通滤波器 Low-Pass (LP) Filter



low pass filter

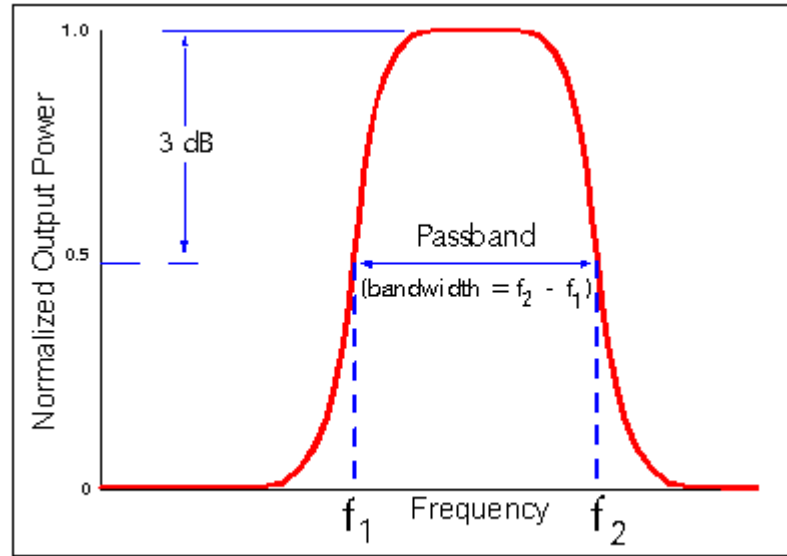
- Use -3dB as the cutoff line

高通滤波器 High-Pass (HP) Filter



high-pass filter

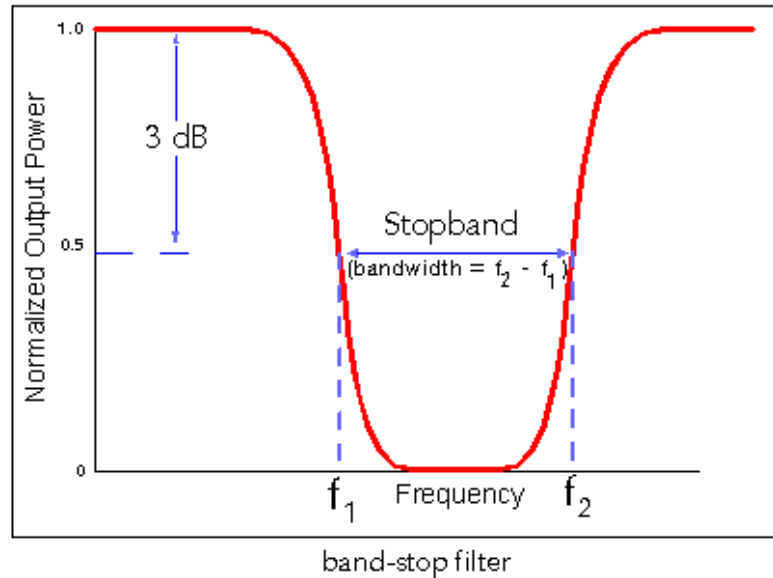
带通滤波器 Band-Pass (BP) Filter



bandpass filter

- Can be formed by combining a high-pass and a low-pass

带组滤波器 Band-Reject (BR) Filter



- Can be formed by combining a high-pass and a low-pass

低通 vs 高通滤波

原始声音



经过低通滤波器 (cutoff at 1,000 Hz)



经过高通滤波器 HP filtered sound (cutoff at 3,000 Hz)



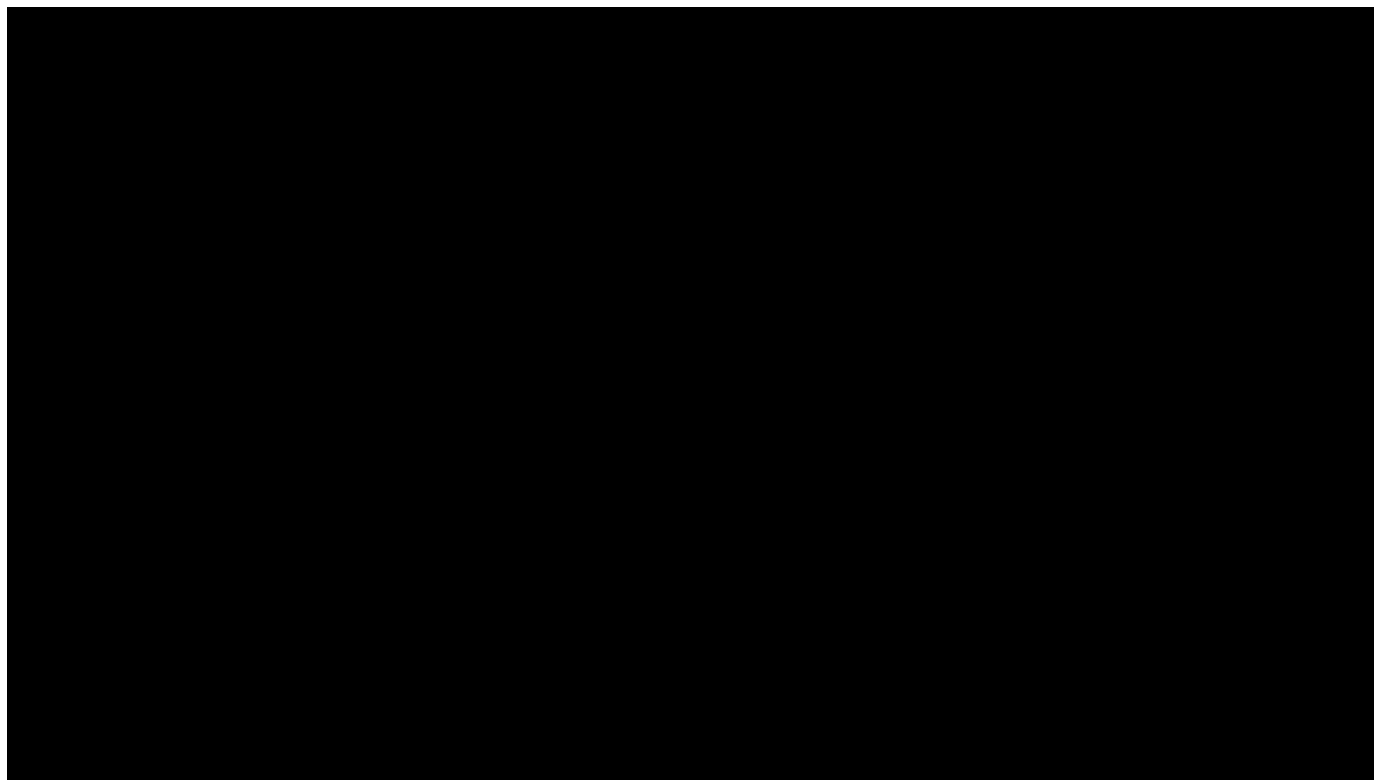
什么时候需要滤波?

- 扬声器系统中的分频电路
- 低音炮、高音扬声器、中频扬声器等适用于不同的频率
- 低音炮：适用于较低频率 (<100 Hz)
- 高音扬声器：适用于较高频率范围
- 中频扬声器

什么时候需要滤波？

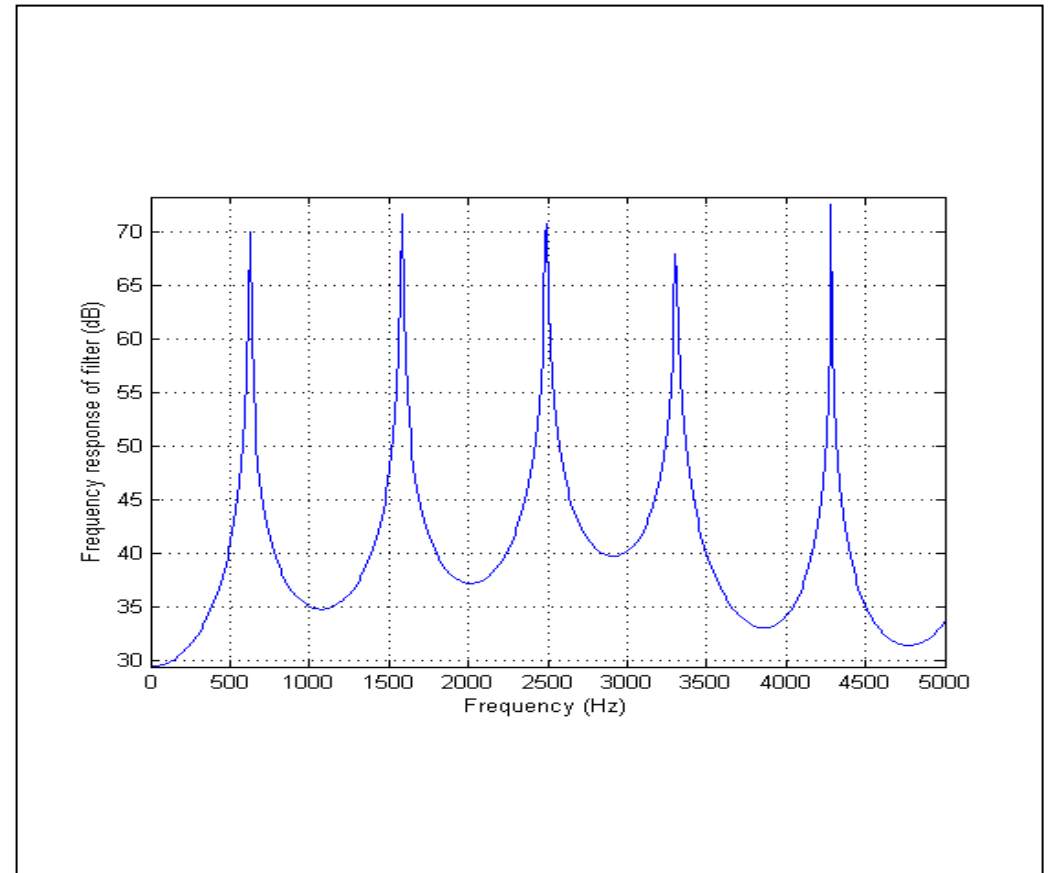
- 当一个信号受到噪声污染（通常由交流嗡嗡声，约60Hz），我们可以通过高于60Hz的截断高通滤波器来摆脱噪声。
- 当我们想要限制信号的带宽时（例如在电话通信中），我们把频率范围调整到一个更小的范围。可以使用带通滤波器

滤波的作用



共振 Resonance

- 共振是选择某些频率的能量进行增强（放大）的过程，而其他频率则会被抑制（衰减）
- 共振器可以是实体装置或软体程序
- 应用在MRI中



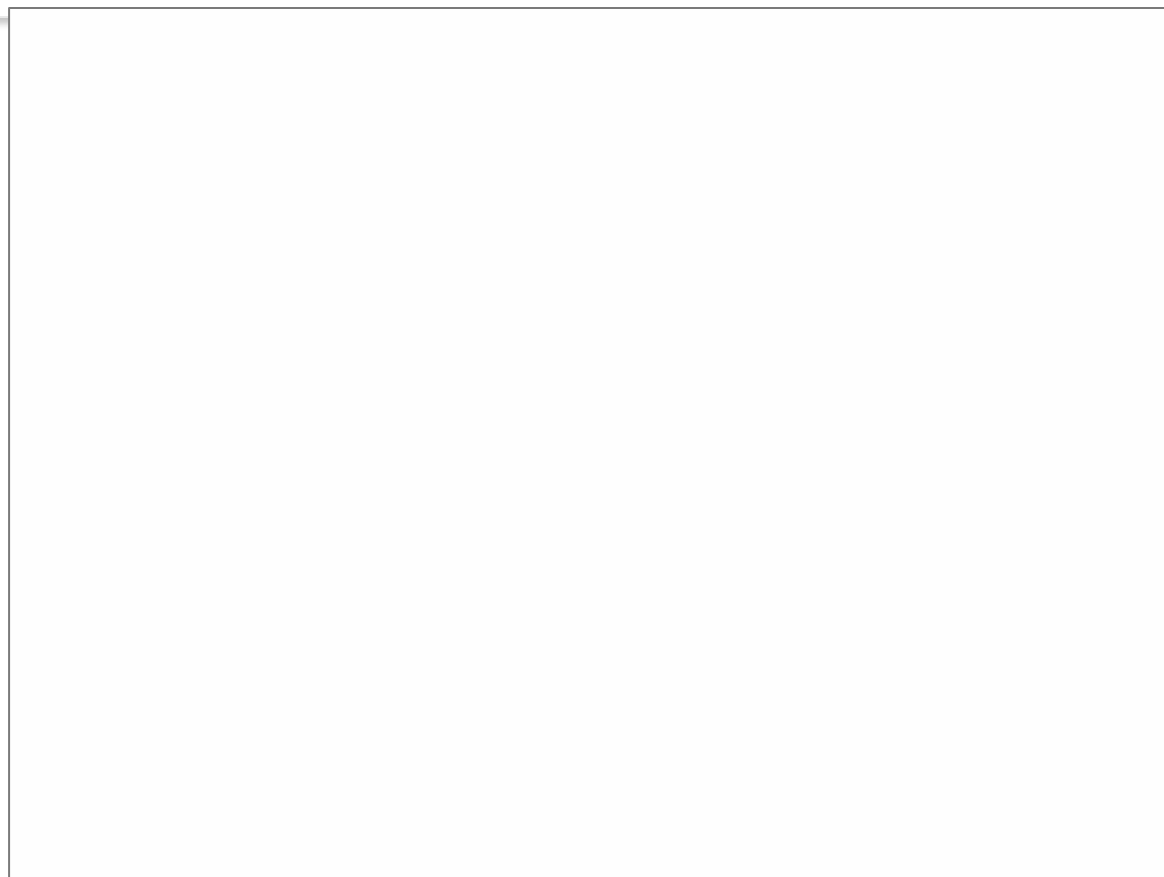
Helmoltz 谐振器



塔科马海峡大桥 Tacoma Narrows Bridge



声音如何打碎玻璃杯？



(00:40)

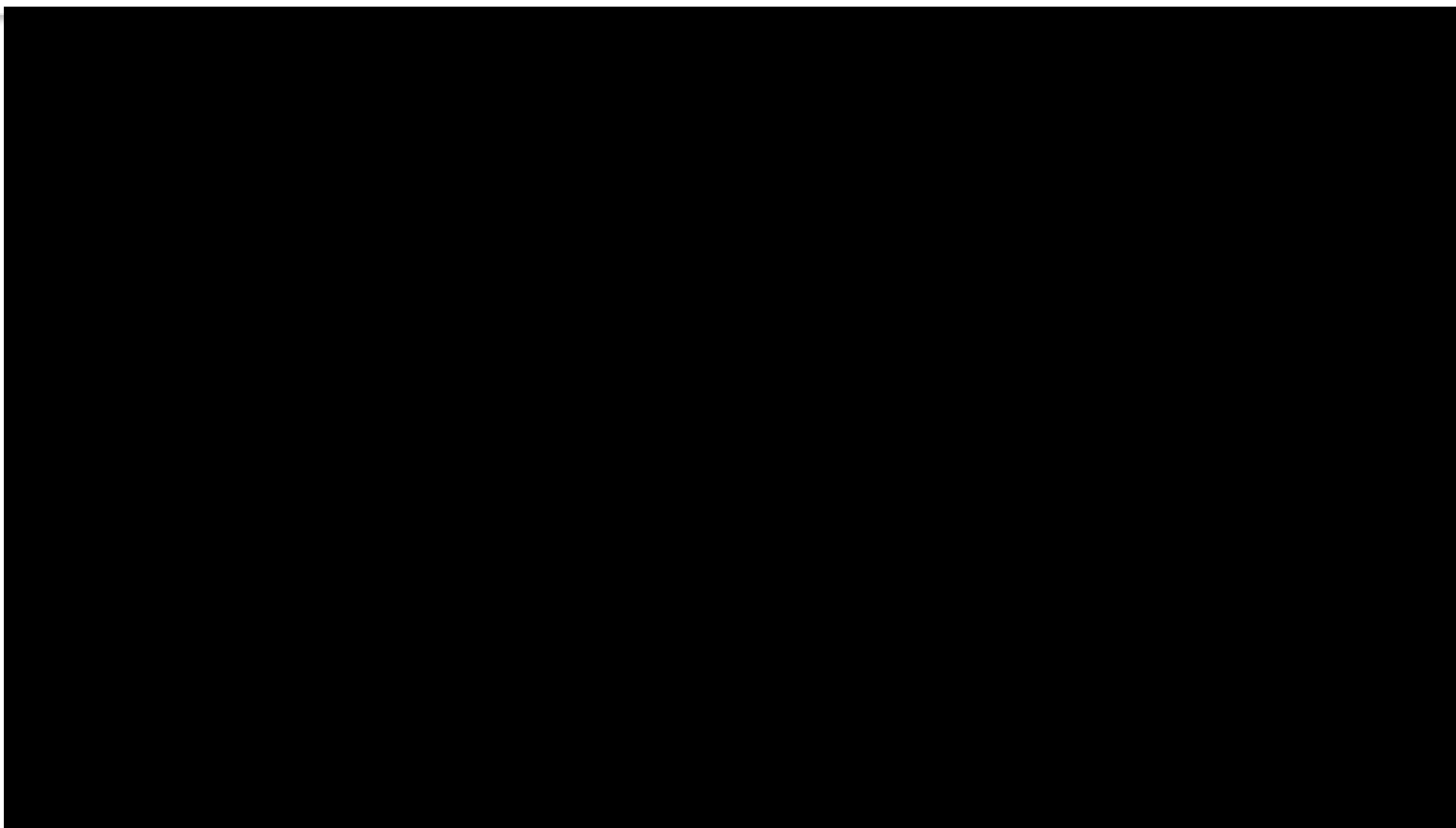
寻找共振频率



共振的工业应用



共振的实验



音响里的平衡器



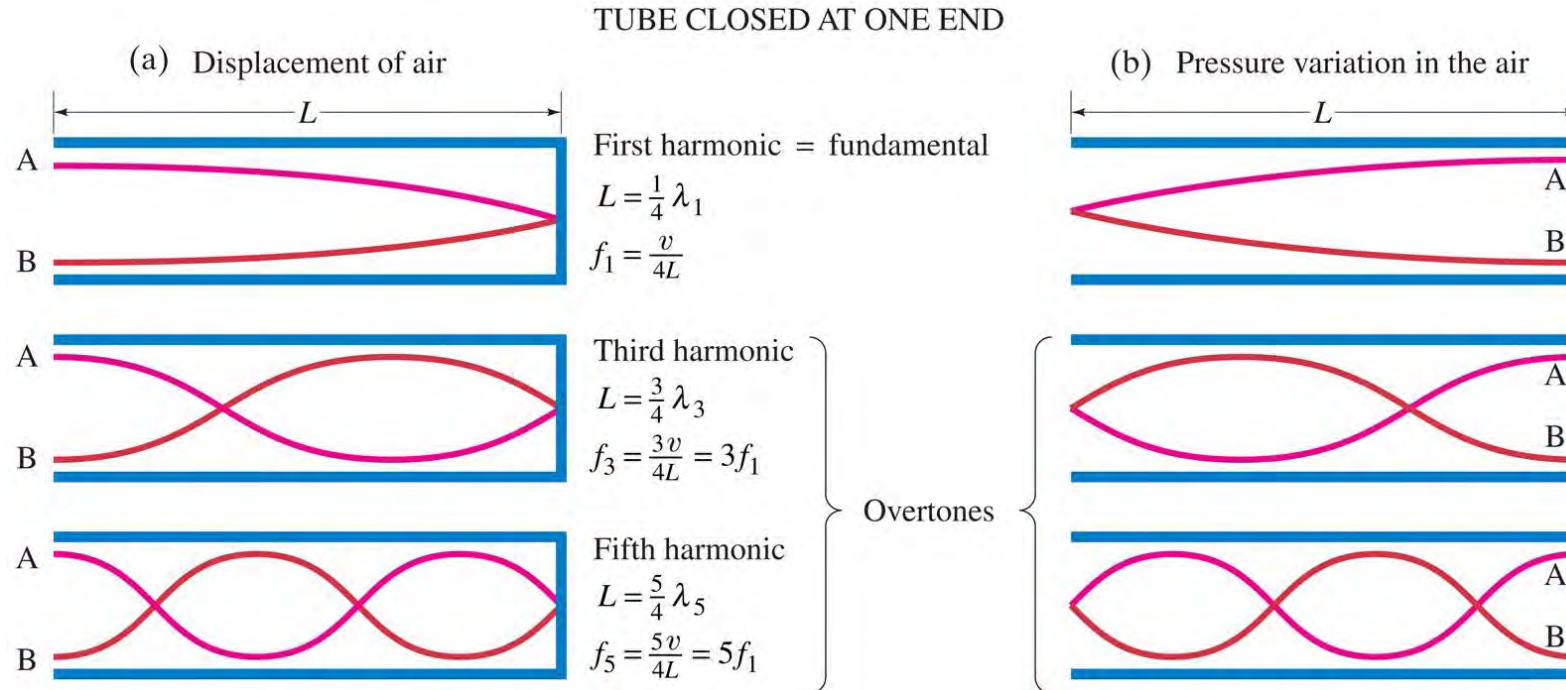
治疗的频率？ 432Hz？

- 432 Hz被称为“自然的和谐调调”，具有特定的治愈特质。

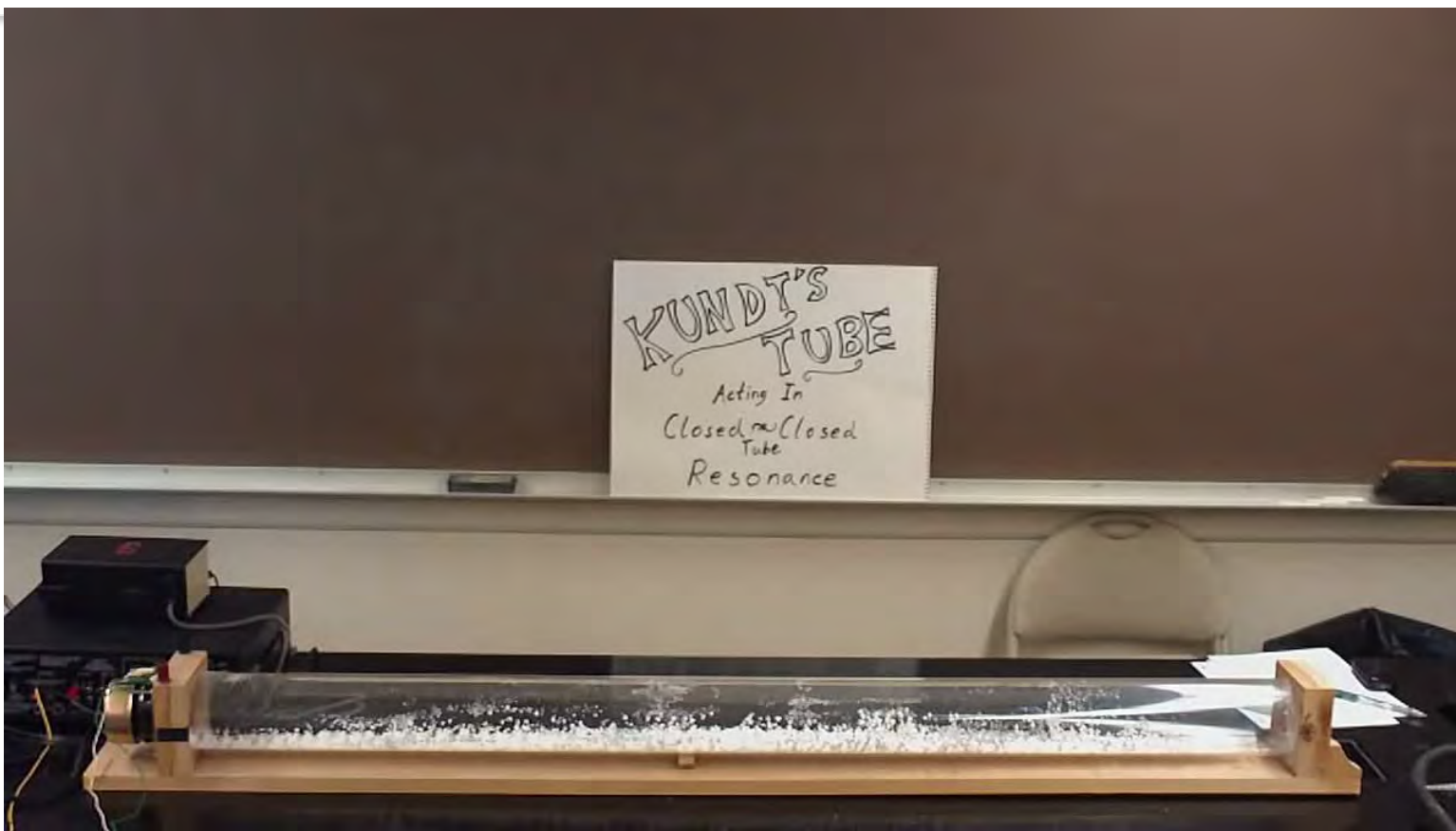
“It is said that 432 Hz vibrates with the universe’s golden mean PHI and unifies the properties of light, time, space, matter, gravity and magnetism with biology, the DNA code, and consciousness. When our atoms and DNA start to resonate in harmony with the spiralling pattern of nature, our sense of connection to nature is said to be magnified. The number 432 is also reflected in ratios of the sun, Earth, and moon, as well as the precession of the equinoxes, the Great Pyramid of Egypt, Stonehenge, and the Sri Yantra, among many other sacred sites.”

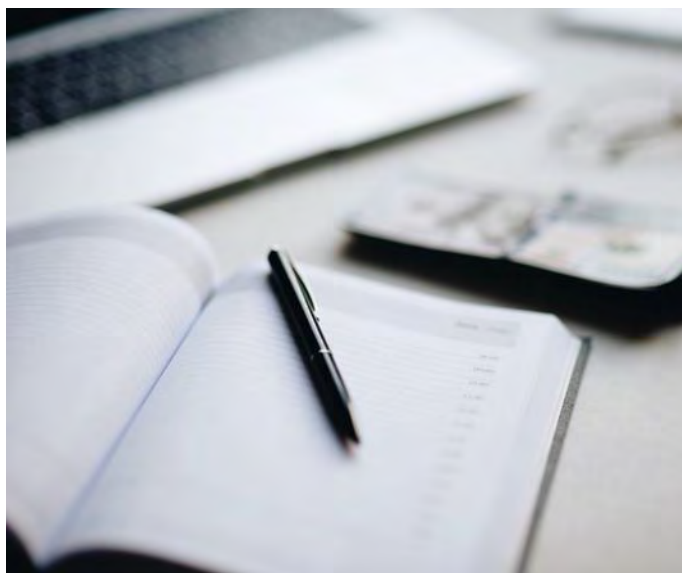
◦ www.collective-evolution.com

闭管共振 Closed-End Tube Resonance



昆特管 The Kundt's Tube





谢谢



吴民华



manwa@hku.hk



manwa-ng.net/futcm