



# **Acoustics of Chinese Bronze Bells**

---

**Chen-Hanson Ting**

**SVFIG**

**January 25, 2020**

# Chinese Bronze Bells





# Bronze Bells

---

- **Chinese perfected bell making in about 500 BC.**
- **In Europe, bell making made major advances in 1600 AD.**



# Bronze Bells

---

- **Chinese bells are oval in shape, and can be tuned easily.**
- **European bells are round in shape, and are very difficult to tune, requiring large, high precision lathes.**



# Degenerate Tones

---

- **Most vibrations in circular bells are degenerate, with two equal frequencies because of symmetry.**
- **Deviations from circular shape cause two degenerate tones to split, and cause beating. Beating tones are unmusical and unpleasant to ears.**



# Degenerate Tones

---

- **Ancient Chinese bell casters chose an oval shape to artificially force a much greater separation of degenerate tones.**
- **The lower central tone can be easily tuned to produce pure and pleasant musical sound.**



# My Bronze Bells

---

- **In 1974-1975, I studied Chinese bells in many Taipei museums.**
- **In 1975 Chiang Kaishiek died, and I got funding to cast a set of bells to his memory.**
- **I kept one of the test bells when I moved to US.**



# My Bronze Bells

---

- **As I had developed the recording of the reed whistles and FFT to analyze the frequency spectrum, the degenerate tones in my bells can now be analyzed precisely.**



# My Bronze Bells



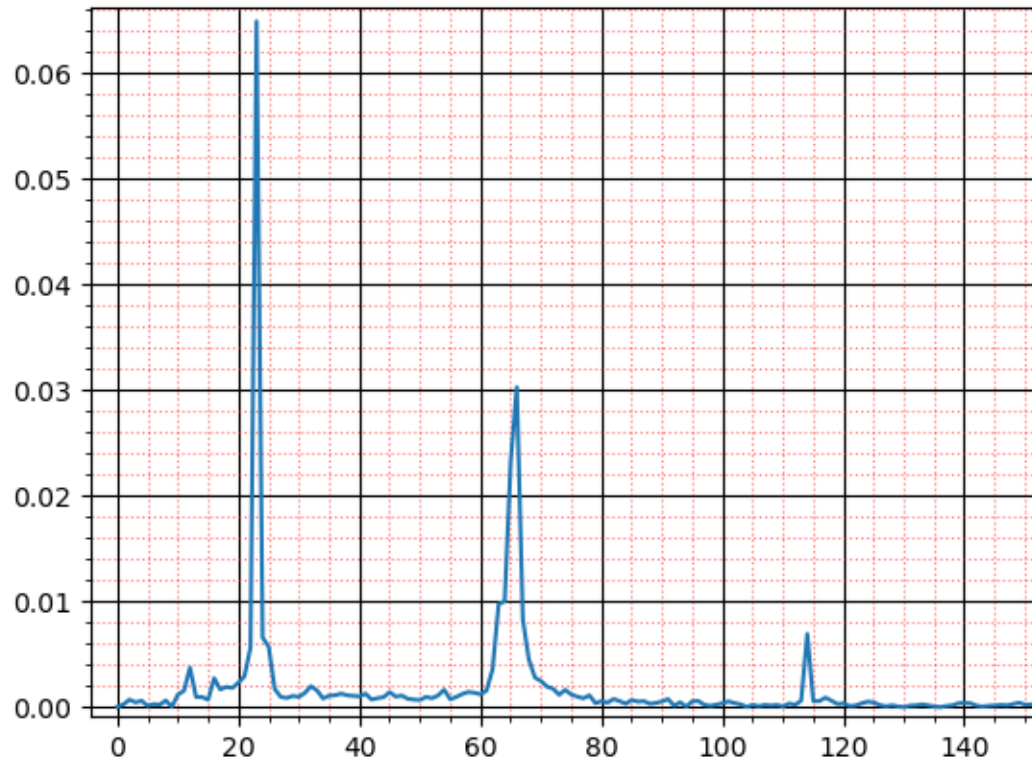


# Two Degenerate Tones

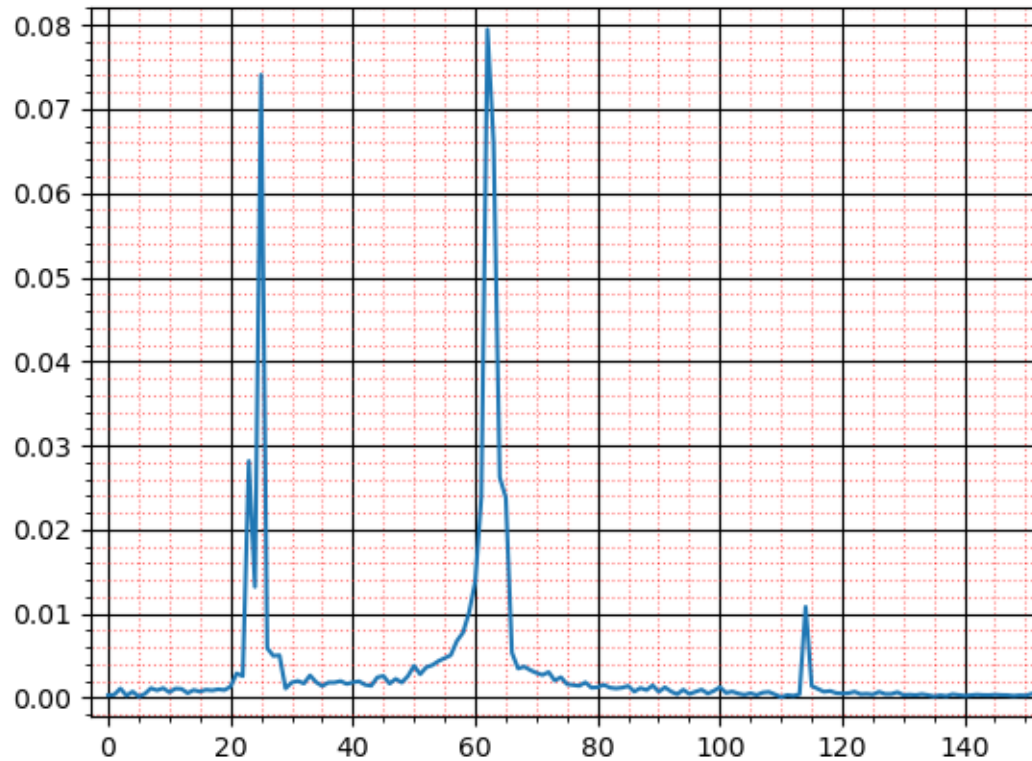
---

- **The lower degenerate tone is produced by striking the center or edges of the bell.**
- **The upper degenerate tone is produced by striking 45 degrees off-center of the bell.**
- **Both tones are produced by striking any other place.**

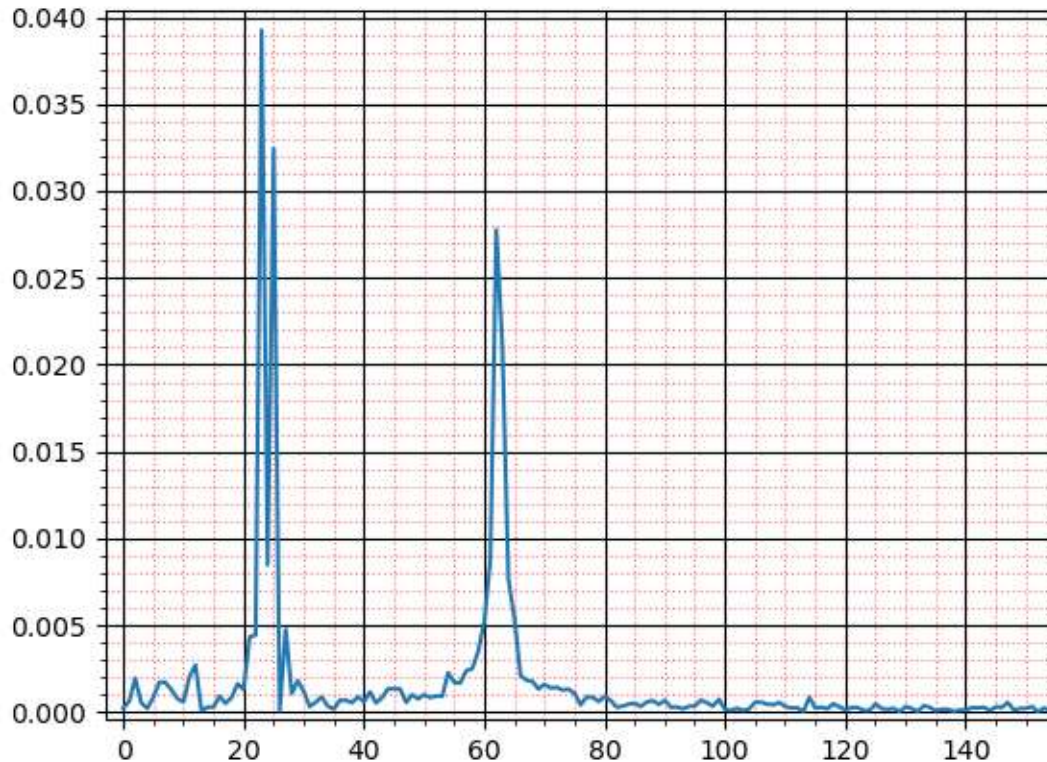
# Lower Degenerate Tone



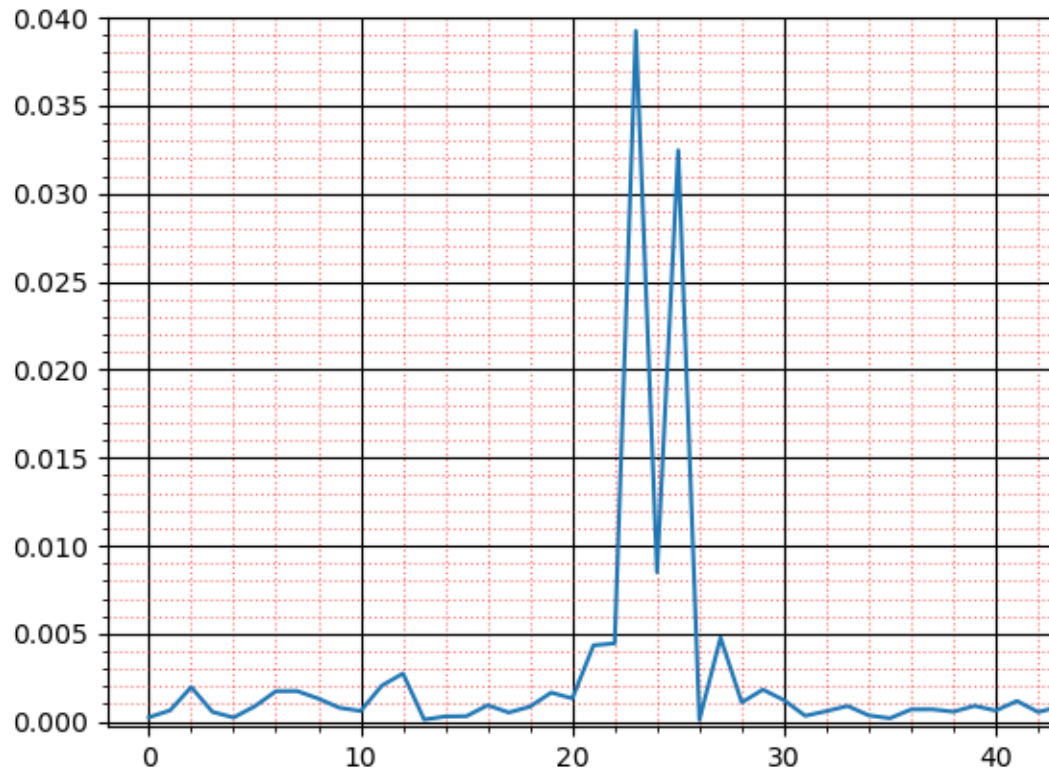
# Upper Degenerate Tone



# Mixed Degenerate Tones



# Mixed Degenerate Tones



# Form to Make Mould



# Mold to Cast Bronze





# Cast Assembly



# Pour Bronze Melt



# Mold Broke Open



# Beautiful Bronze Bells



# Original Bell Set

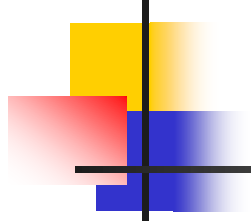


# Original Bell





**Questions?**



---

**Thank You!**