Modelling the Effect of Temperature on Resonant Frequencies with a Standard Trumpet

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BACKGROUND

- Professional musical ensembles
  - Importance of intonation
- Indoor vs outdoor performance environments
  - Example: Trumpet pitch accuracy test

SOUND WAVES

- The speed of sound and temperature
- Kinetic energy
- $v=f\lambda$

RESEARCH QUESTION

- Does changing the ambient temperature of a trumpet cause a significant enough resonance frequency shift to result in pitch accuracy discrepancies?

HYPOTHESIS

- Resonant frequencies will experience a shift upwards as the ambient temperature increases because the speed of sound is increased.

EQUIPMENT

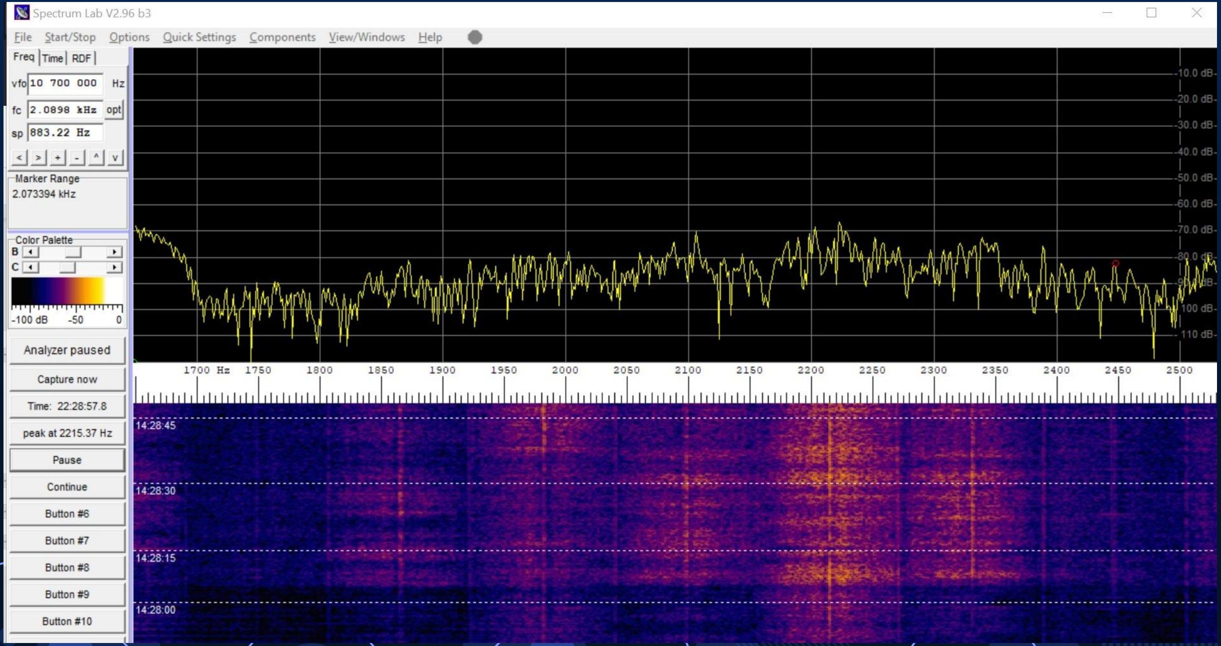
- Silver-Plated Brass Trumpet
- Microphone & Wire
- *Spectrum Lab* program on a Laptop, connected to wire mic
- Bluetooth speaker playing white noise; pure tones (using *Audacity*)

FAMILIARIZATION

- Pure Bb tone played directly into mic
- Data taken, Spec Lab paused and unpaused

RESULT:

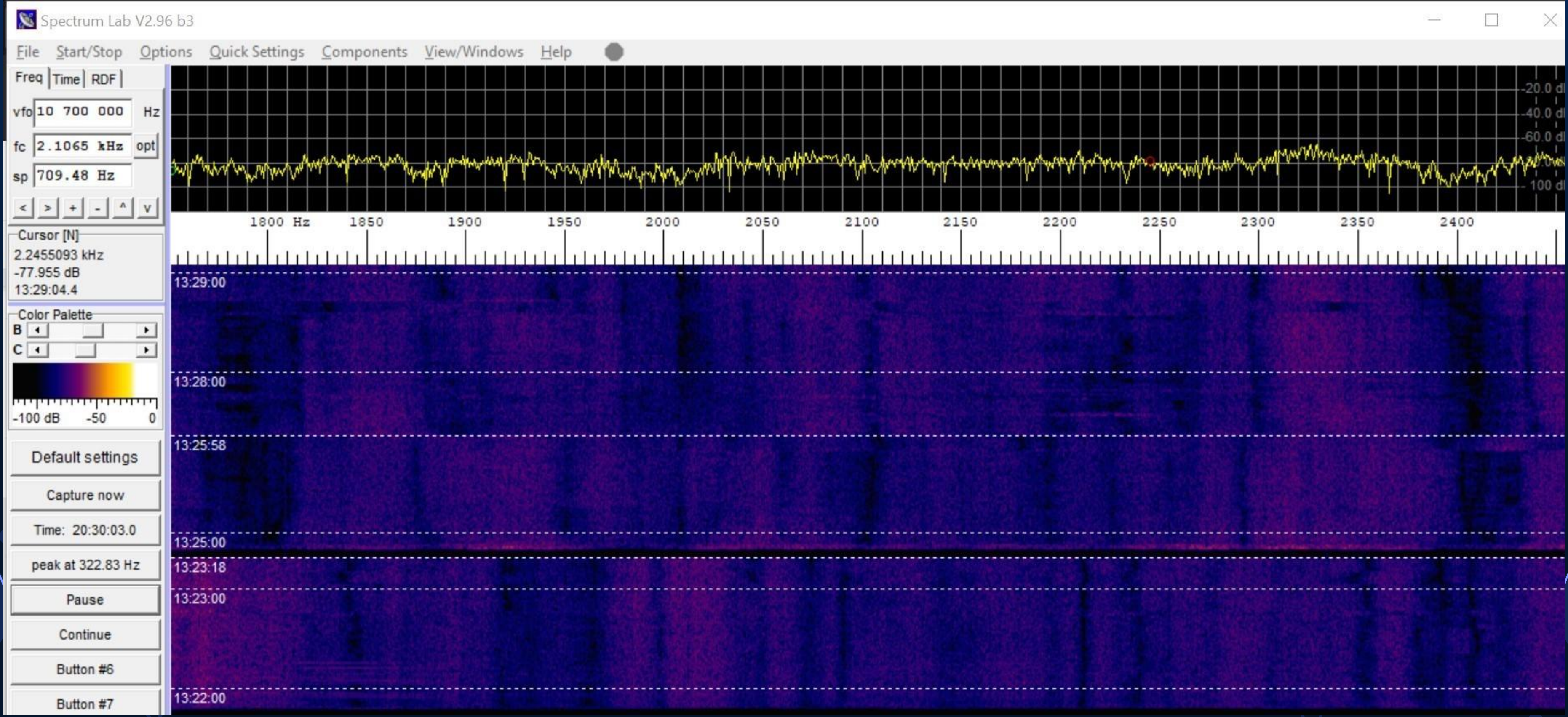
No observable shift when temp remains constant



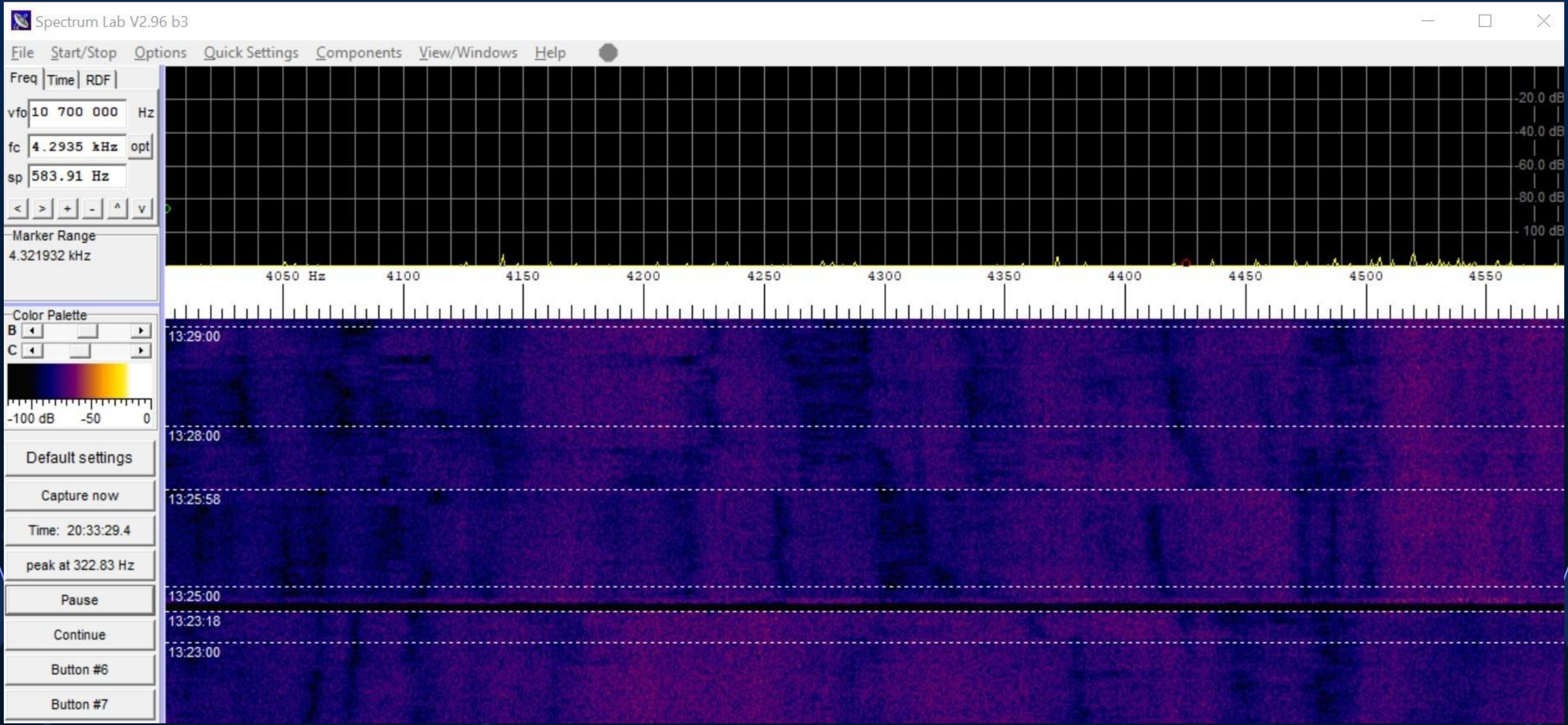
CONTROL

- Control method: 3 different data-taking rounds: Cooled, Room Temperature, and Heated
- Resonance frequency increased with each temperature increase

CONTROL: Pt 1/2



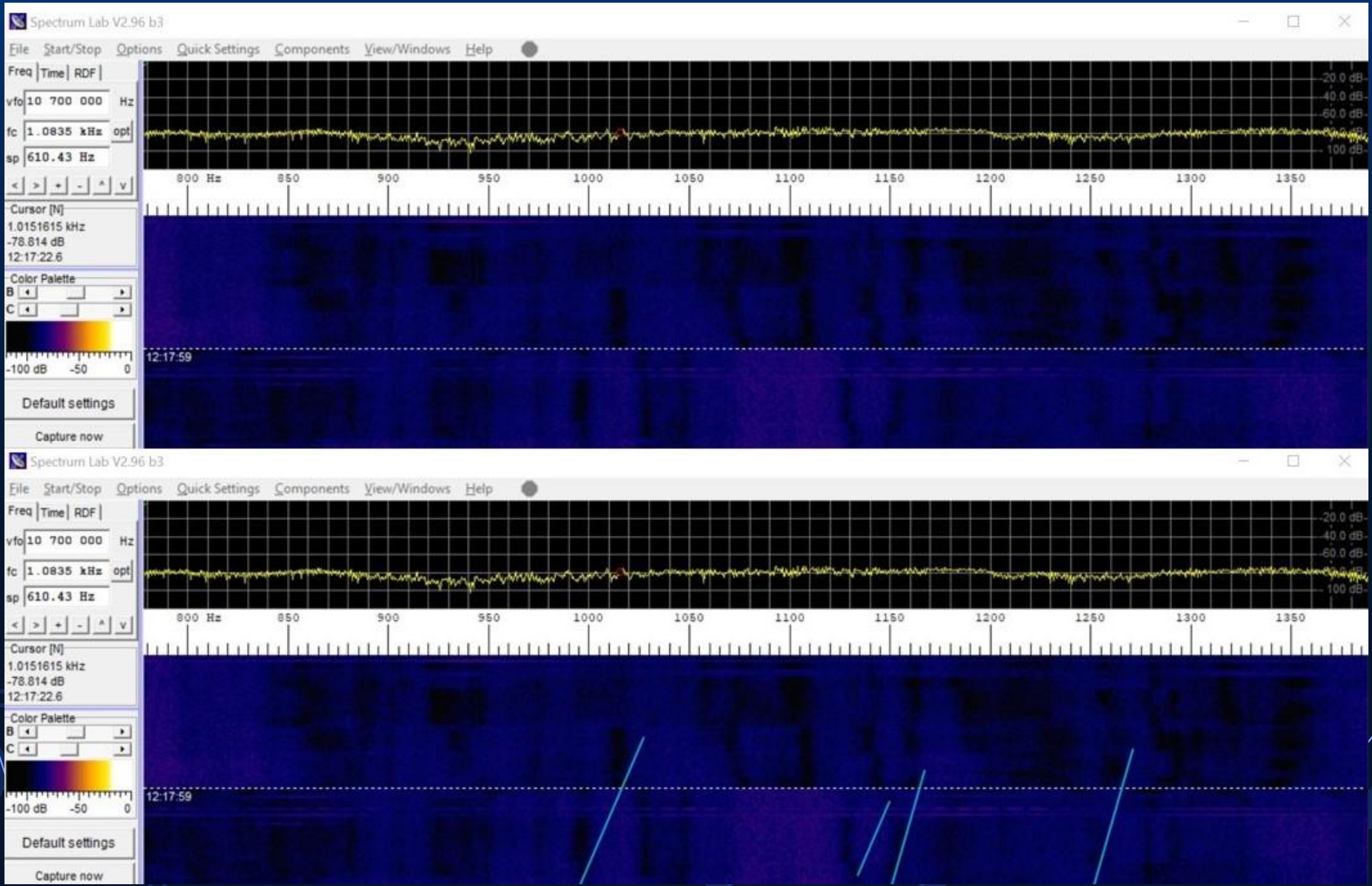
CONTROL: Pt 2/2



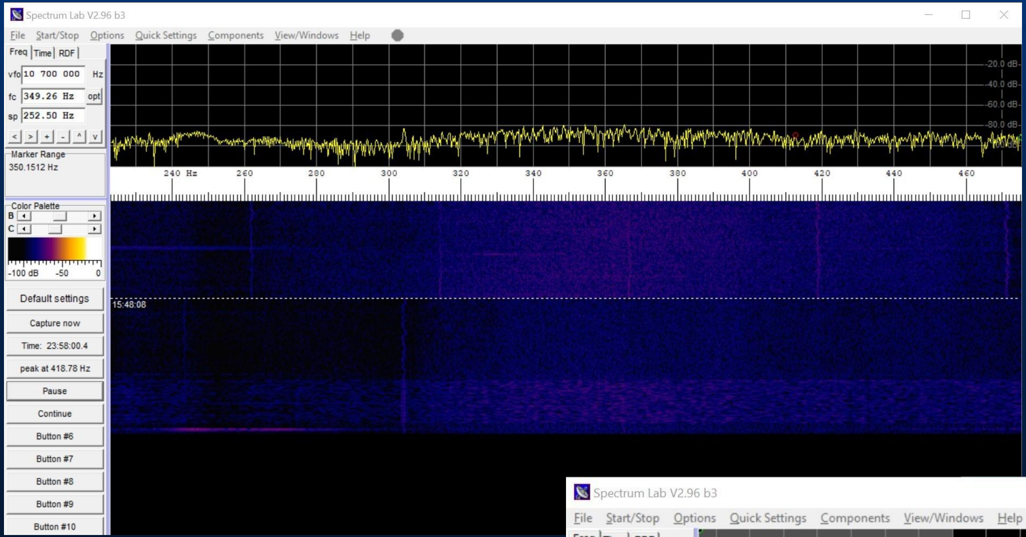
METHOD

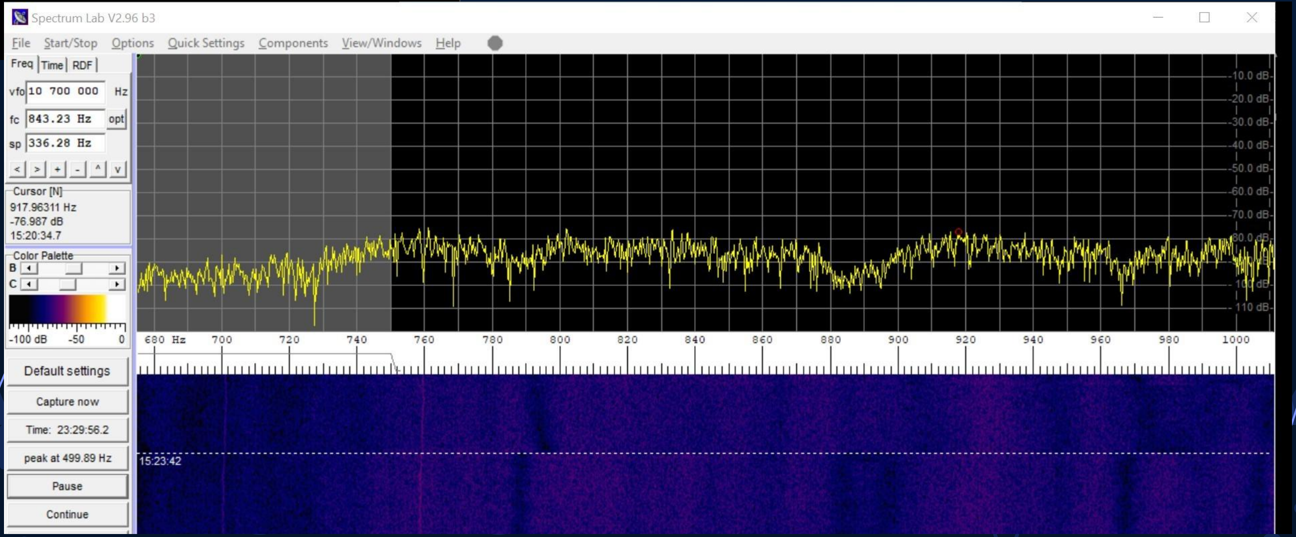
1. Initial Setup
2. Cooling phase
   2.1. Exposed to outdoor air until internal temperature approx 5°C
   2.2. Recording # ½: Spectrum Lab collected data for 3 mins, then paused
3. Heating phase
   3.1. Exposed to hair dryer until internal temperature approx 30°C
   3.2. Recording # 2/2: Spectrum Lab unpaused, data taken for another 3 mins
4. Compare & Analyse
   4.1. Changes in resonance frequencies between treatments compared

RESULTS: EXAMPLE GRAPH



EXAMPLES OF SPECTRUM LAB MEASUREMENTS PT 2.





TABULATED RESULTS

Δf #	Δf (Hz)	Scale (Hz)	u[f] (Hz)
2A	20.0	5.0	1.3
2B	15.0	5.0	1.3
2C	15.0	5.0	1.3
3A	20.0	2.0	0.5
3B	12.0	2.0	0.5
3C	12.0	2.0	0.5
4A	20.0	5.0	1.3
4B	20.0	5.0	1.3
4C	13.0	5.0	1.3
4D	13.0	5.0	1.3
5A	25.0	50.0	12.5
5B	20.0	50.0	12.5
Δfw	15.2		
u[Δfw] (Hz)	0.2		

RESULTS ANALYSIS

- Resonance frequency areas of density consistently shift sharper (in positive, right direction on graph)
- Average weighted difference of around 15 Hz between cold and hot conditions

DISCUSSION

- Semitones and frequencies
- $n=[\Delta f \wedge (\sqrt[12]{2})]^{*}100\%$
- shift upwards of less than one semitone
- Approximately 17%
- Comparison between trials- Inter vs Intra

LIMITATIONS

- Spectrum Lab
- Frequency Shift Measurement Uncertainty

IMPLICATIONS

- Future investigations
- Outdoor performances

CONCLUSION

- Experimental results support hypothesis that the resonance frequencies of a trumpet become sharp when the ambient temperature is increased.

BIBLIOGRAPHY

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