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Musical Acoustic Comparative Study between the Double Top and Lattice Bracing guitar models by

Fernando Mazza

Full Version

Study conducted by Enrique Mateu, guitarist, and music producer,
commissioned by Fernando Mazza.

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Construction

Lattice Bracing and Double Top guitar models.

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In this musical acoustic study, the guitars being compared are the Double Top and Lattice Bracing models by luthier Fernando Mazza.

Both guitars have the soundboard constructed in an identical manner. The sides are made up of six layers of Santos Rosewood with a central layer of maple with crossed grain to generate more rigidity in the structure.

The back of these guitars is double with a nomex core. This wood and nomex composite provides rigidity without increasing the weight of the back.

The laminated soundboard increases the rigidity of the entire guitar structure, allowing the vibration energy emitted by the strings to be absorbed more intensely in the soundboard than in the rest of the guitar structure.

The bridge of the guitar is smaller than that of a traditional guitar to reduce weight and facilitate the mechanical movement of the soundboard.

Both the Lattice and Double Top models studied here have Red Cedar soundboards.

The tuners are Schaller Grand Tune and the fretboards are ebony with 20 frets on both models.

All measurements were taken using Knobloch Actives CX Carbon Medium High 400ADC strings.

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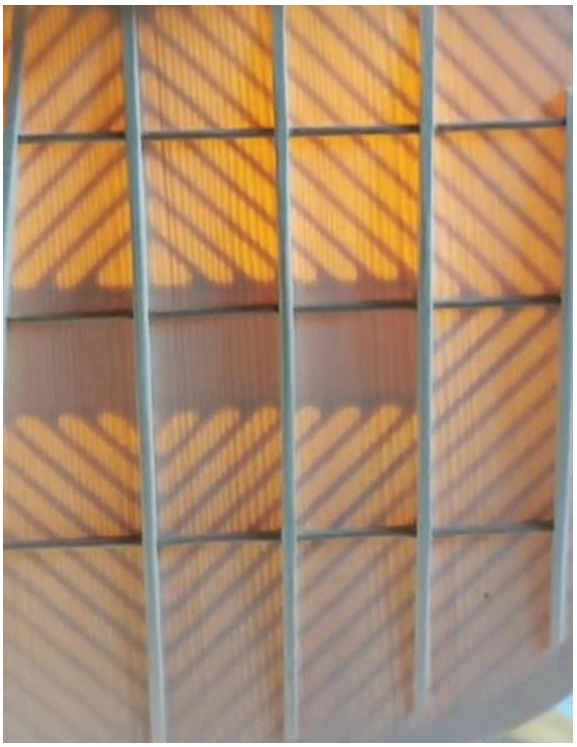
Double Top Model

The design of this soundboard consists of an extremely thin outer top with a cutout where a balsa wood structure is inserted, as we can see perfectly in this photo.

Upon this structure, a second very thin top is glued, forming a kind of flexible but at the same time rigid and lightweight sandwich. On top of the second top, the spruce wood bracing, also designed by Fernando, is glued. This bracing provides the guitar with rigidity and uniform vibration across the entire surface of the soundboard.



Detail of the finished double top soundboard with its bracing.

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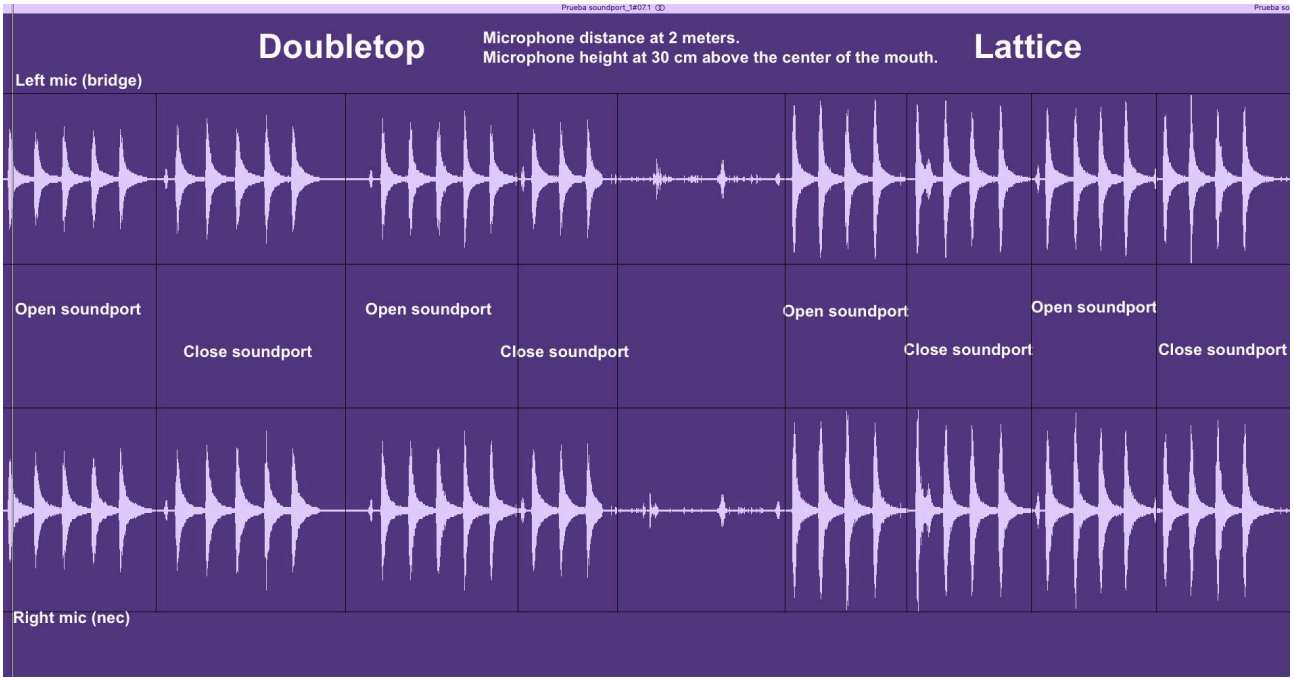
Lattice Bracing Model

This model features an extremely thin soundboard, also made of cedar or spruce wood (the one used for the study is cedar), with a lattice-like pattern in the shape of diamonds, set at a specific angle, made of balsa wood and inserted into an identical recess in the soundboard. Directly above the lattice, there is an identical structure made of carbon fiber, which is also vacuum-glued. In the photo, you can see this type of soundboard unfinished, as it does not yet have the carbon fiber.

Volume and Projection

For this test, a thumb-strummed arpeggio was executed with all strings open, both with the soundport open and closed. For this purpose, two microphones were placed 2 meters away from the instrument and raised 30 cm above the center of the guitar's soundhole, in an A/B position.



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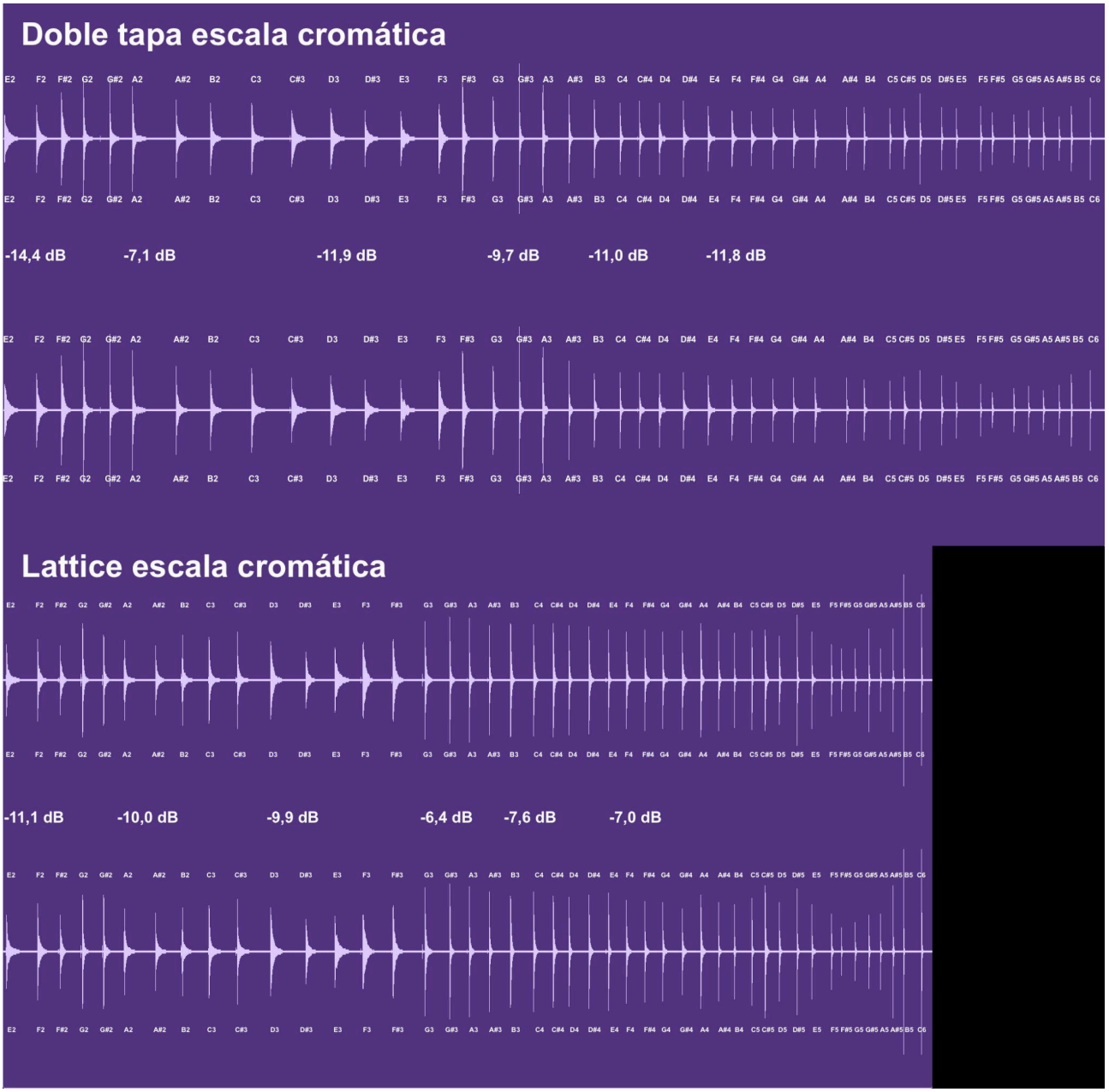
It's clearly noticeable the difference in volume between the Double Top and the Lattice Bracing, with the latter projecting the most.

In the following graph, you can observe a chromatic scale from the lowest note (E2) to the highest (C6) on both instruments. Additionally, you can see the sound pressure (volume in decibels) of the six open strings.



In the previous graph, it's evident that there's a difference in volume between the Lattice Bracing and the Double Top models, up to +3 dB in the bass strings and +4.8 dB in the trebles. This is a significant difference in favor of the Lattice Bracing model in terms of sound power.

From the perspective of balance, the Lattice Bracing model emphasizes the mids more, while in the Double Top model, the bass and trebles seem more balanced.

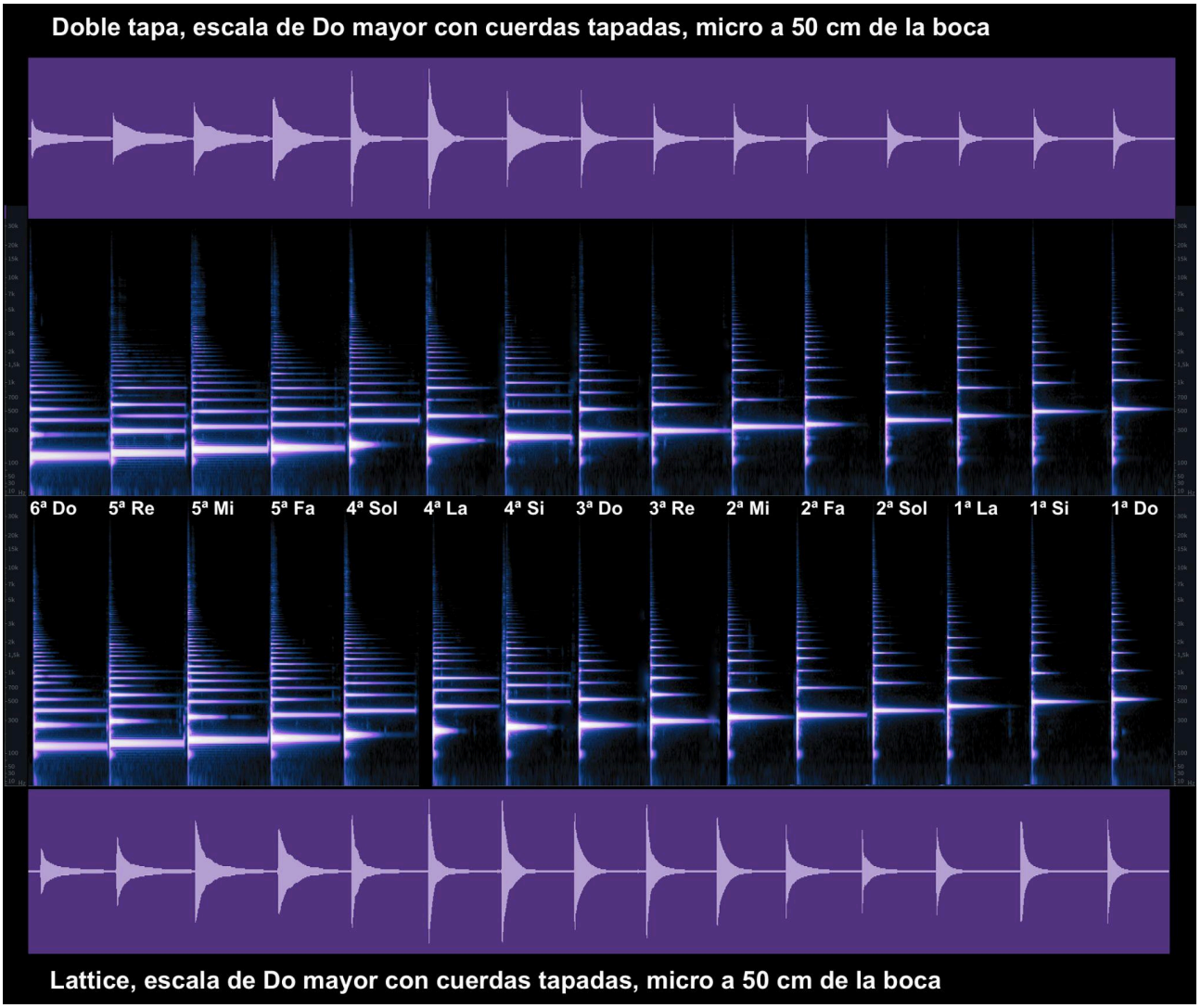
Later on, we'll discuss the resonance of these instruments (sustain and decay).

All these measurements were taken using Knobloch Actives CX Carbon Medium High 400ADC strings installed on both guitars.

It's important to note that in these measurements, 0.0 decibels, dB from now on, represent maximum volume, and -infinity, -∞ from now on, represents the absence of sound. This means that -1.3 dB is louder than -2.5 dB. Conversely, -1.5 dB is less sound pressure than -0.2 dB. The closer to 0.0 dB, the higher the sound pressure.

For this test, two microphones were placed 54 cm away from the instrument, at the height of the guitar's soundhole, in an A/B position with 18 cm between them.

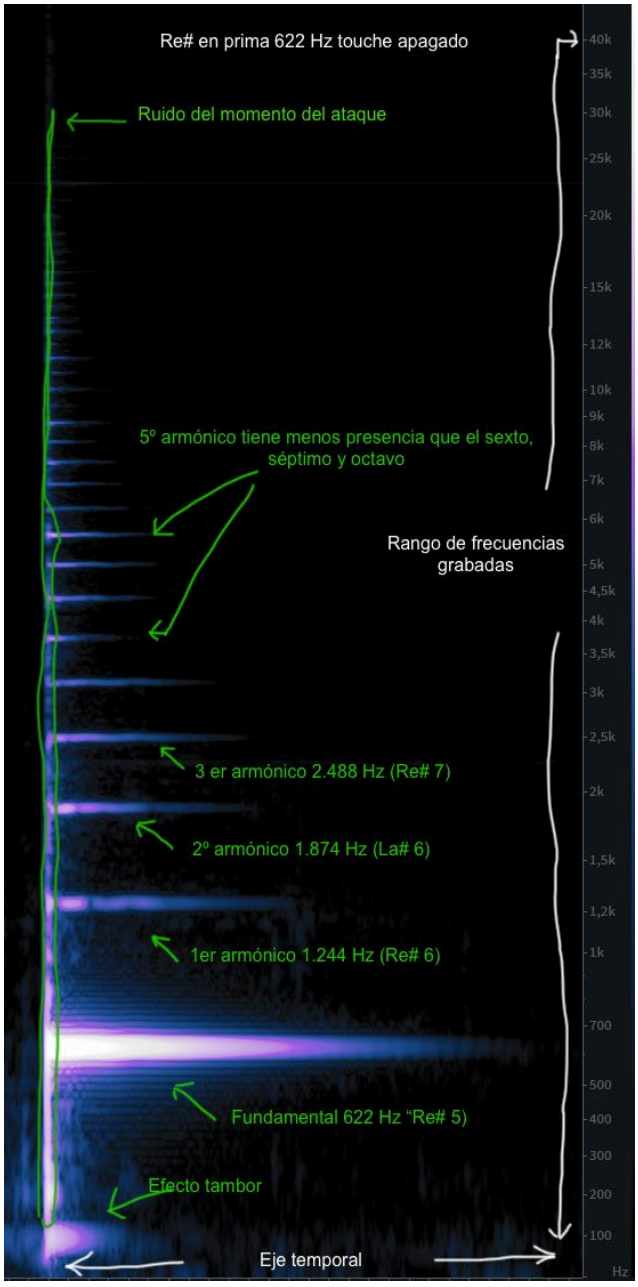
In the graph on the next page, a C major scale is represented with a mute placed to prevent the open strings from resonating. Recorded with a microphone 50 cm away from the instruments at the height of the soundhole.



At this point, it's important to clarify that all measurements taken with different guitars systematically exhibit different behaviors in each note, string, and position. This is absolutely normal, although the goal is always to make these differences as subtle as possible. However, the characteristics of the strings also play a role here, including their material, thickness, tension, etc.

Regarding volume, in the purple strip, we observe a crescendo as we reach the middle strings (4th and 3rd), followed by a decrease again. In both instruments, it's noticeable how the fundamentals on the third string (G and A) quickly decay while the first harmonic

is sustained. This is more pronounced in the Lattice Bracing model, which also occurs on the second string, albeit to a lesser extent.

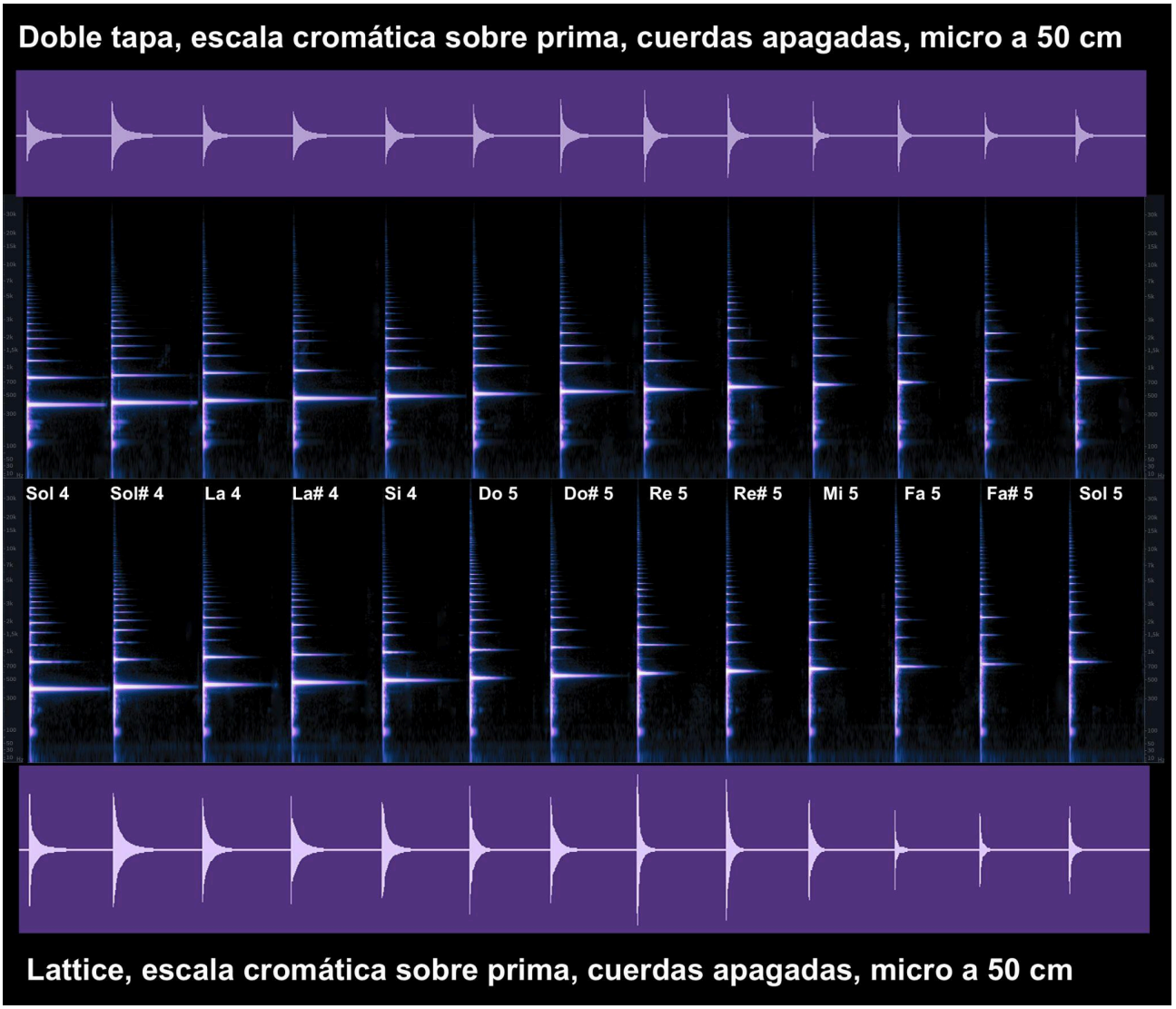


As for the stability and balance of harmonics, the Double Top model offers a slightly better result. For example, while the C on the sixth string and its first harmonic (261.63 Hz) have little presence in the Double Top, in the Lattice Bracing, it's noticeable that there's little presence in the C, D, and E. When we combine this with the previously mentioned fundamentals on the third and fourth strings in the Lattice Bracing, it's clear that the Double Top offers a slightly better balance. However, we'll address these issues in more detail in the section on the instruments' timbre.

To interpret the spectrogram (left figure), we must consider that frequencies from 0 Hz to 40,000 Hz (humans only hear from 20 to 20,000 Hz) are represented on the y-axis. The x-axis represents time in seconds. White color represents maximum energy (volume) from 0.0 to -42.0 dB, purple represents medium volume from -42.0 dB to -64.0 dB, blue represents low volume from -64.0 dB to -100.0 dB, and black represents an appreciable absence of sound.

Notice how at the attack moment, there's a very brief noise across all frequencies that produces a low resonance, known as the 'drum effect,' at frequencies below 100 Hz. This drum effect dissipates when we move a few meters away from the instrument.

In the following test, a chromatic scale executed on the high E string is compared.



Here, too, the greater sound pressure of the Lattice Bracing model is evident, but there's a slight more coherent balance in the Double Top.

In both models, it can be observed that D5 is the note that emits the most energy. We must remember that the rest of the strings are muted, so they don't influence their resonance in these tests.

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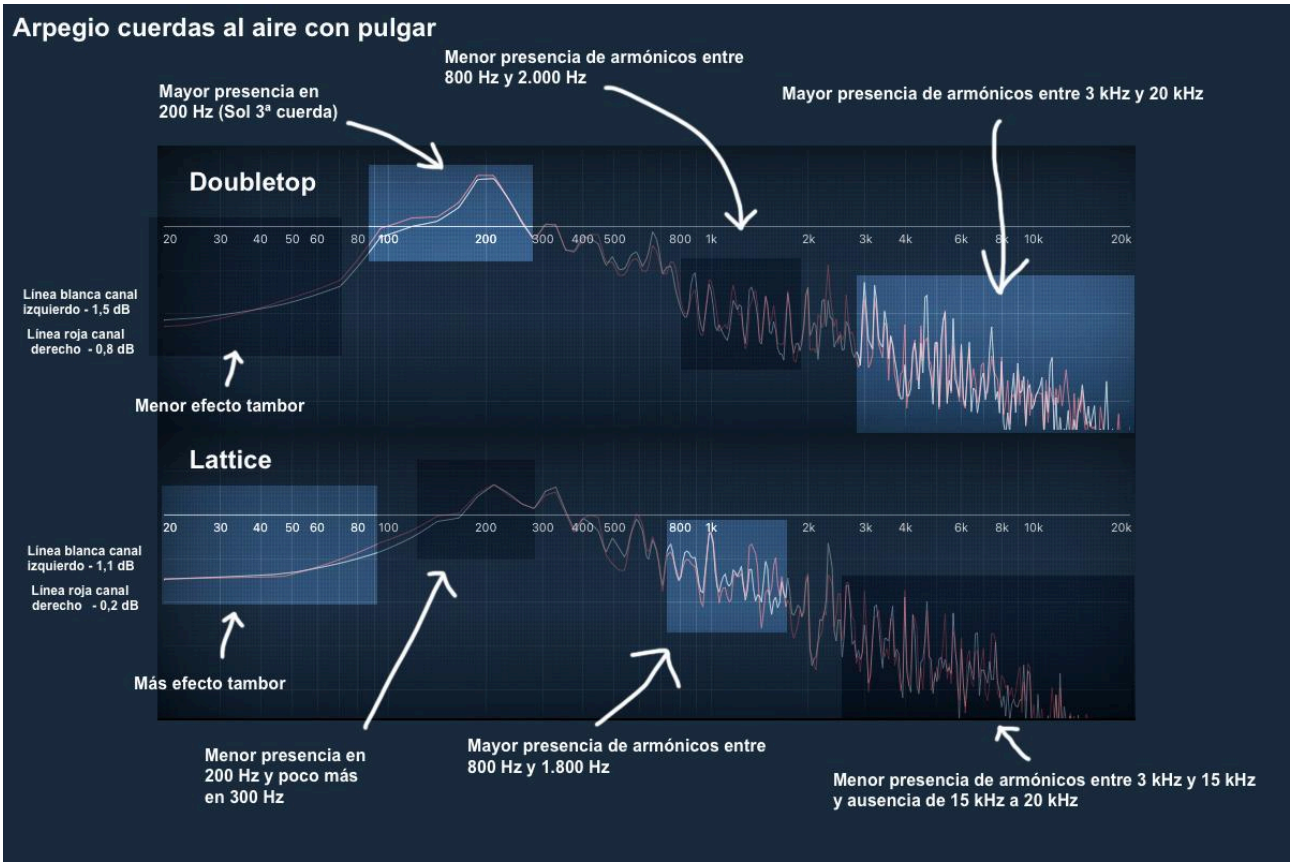
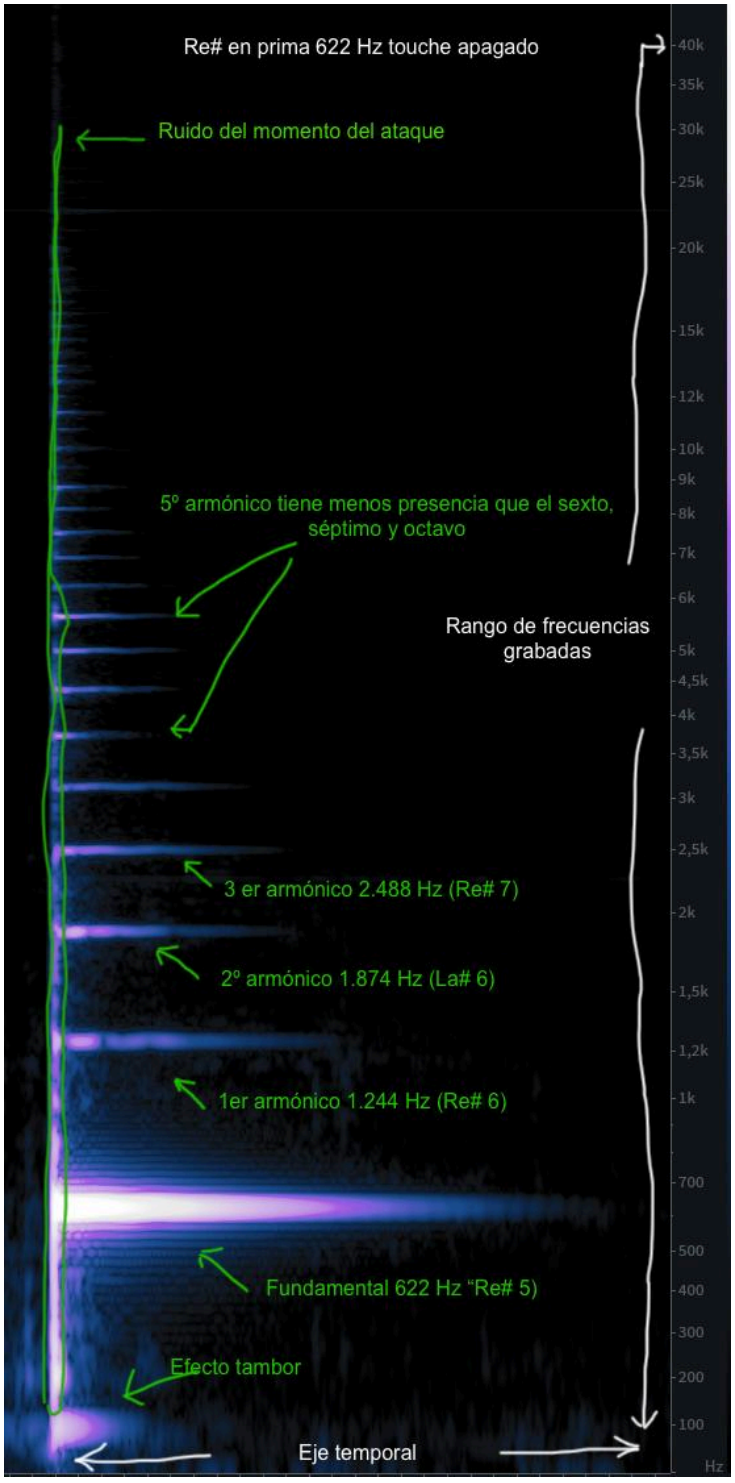
Timbre

Timbre is defined by the behavior of the harmonics. In the following figure, the analysis of the harmonics of a strummed chord with open strings recorded with two microphones placed 54 cm away from the instrument, at the height of the guitar's soundhole, in an A/B position with 18 cm between them, can be observed.



The x-axis represents the frequency range in Hertz from 20 to 20 kHz (20,000 Hz), and the y-axis represents volume. The white line represents the left channel (microphone positioned beneath the bridge), and the red line represents the right channel (microphone positioned beneath the end of the fretboard).

From a timbral perspective, it can be observed that the Double Top guitar offers greater



presence in the low frequencies (70 to 200 Hz) and high frequencies (3 kHz to 20 kHz) compared to the Lattice Bracing, where mid-range frequencies (800 Hz to 1,800 Hz) predominate.

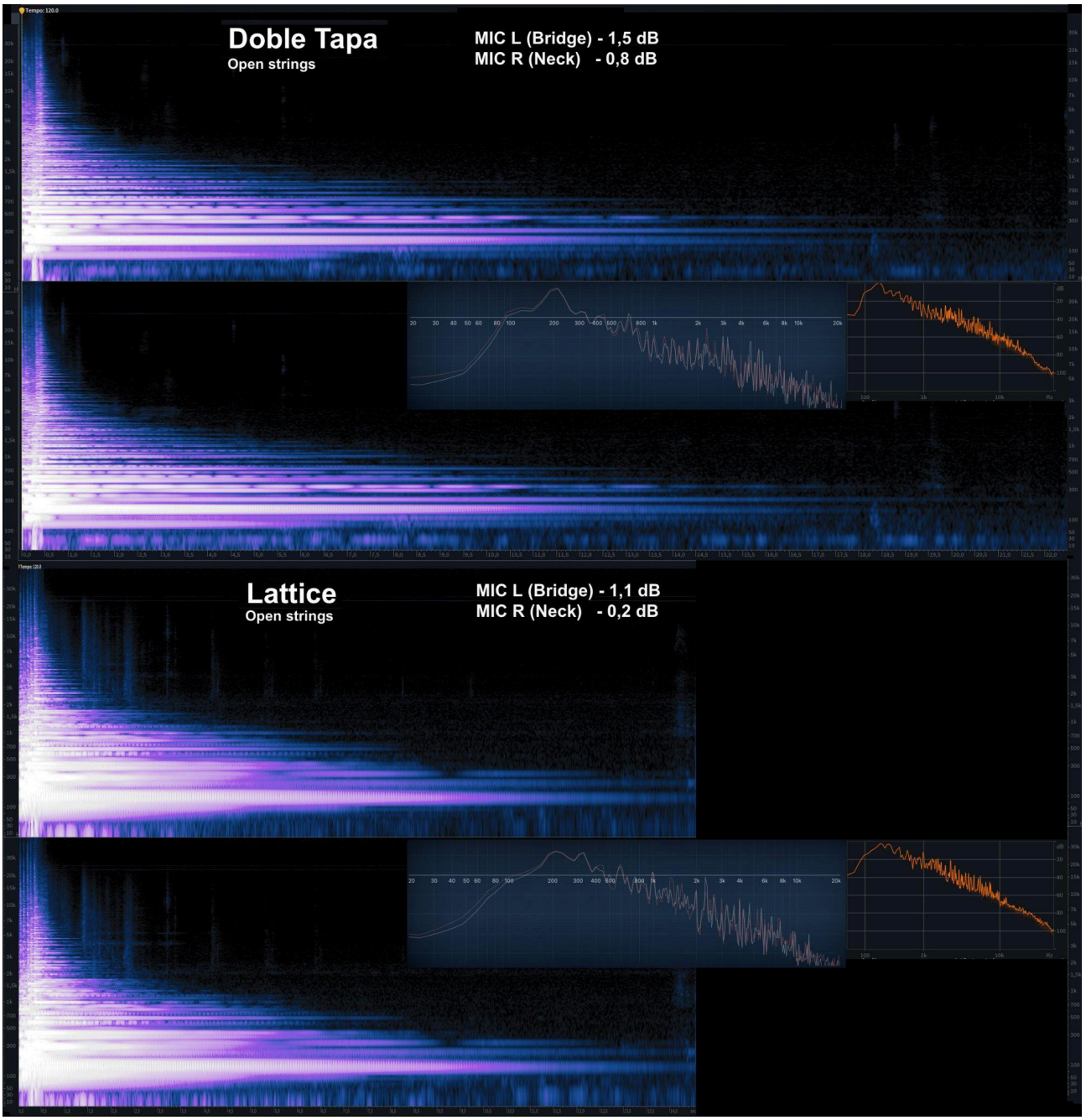
This amplification of frequencies from 800 Hz to 1,800 Hz in the Lattice Bracing is what some refer to as 'nasal sound.' On the other hand, the lower presence of frequencies between 3 kHz and 15 kHz in the Lattice Bracing is what some refer to as 'sweet sound.'

The Double Top model offers a more balanced sound between mid and high frequencies, providing a tonality closer to traditional spanish guitar, greater transparency, and better definition.

The left graph explains a spectrogram.

Regarding the so-called drum effect, the noise produced when fingers or a plectrum strike the strings in plucked string instruments, which is clearly visible in this image, seems to be slightly more pronounced in the Lattice Bracing model.

It should be clarified that this noise is more perceptible the closer the microphones are placed to the instrument, both due to the so-called proximity effect and the natural loss of low frequencies with distance.



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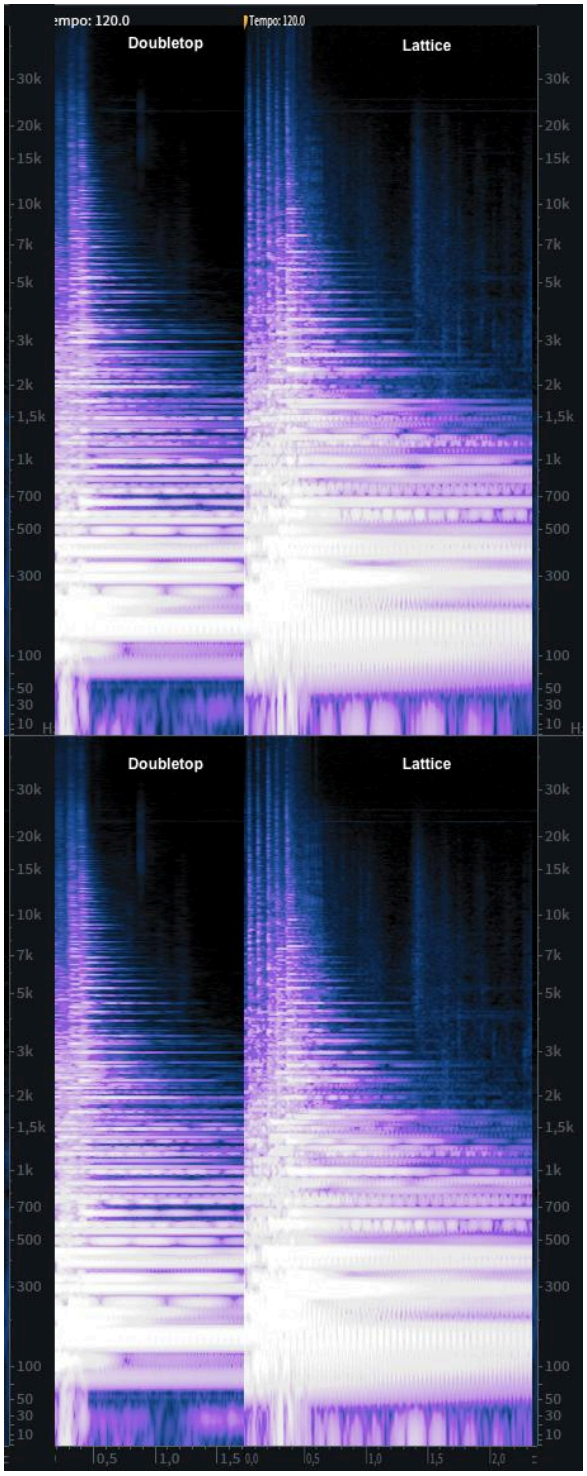


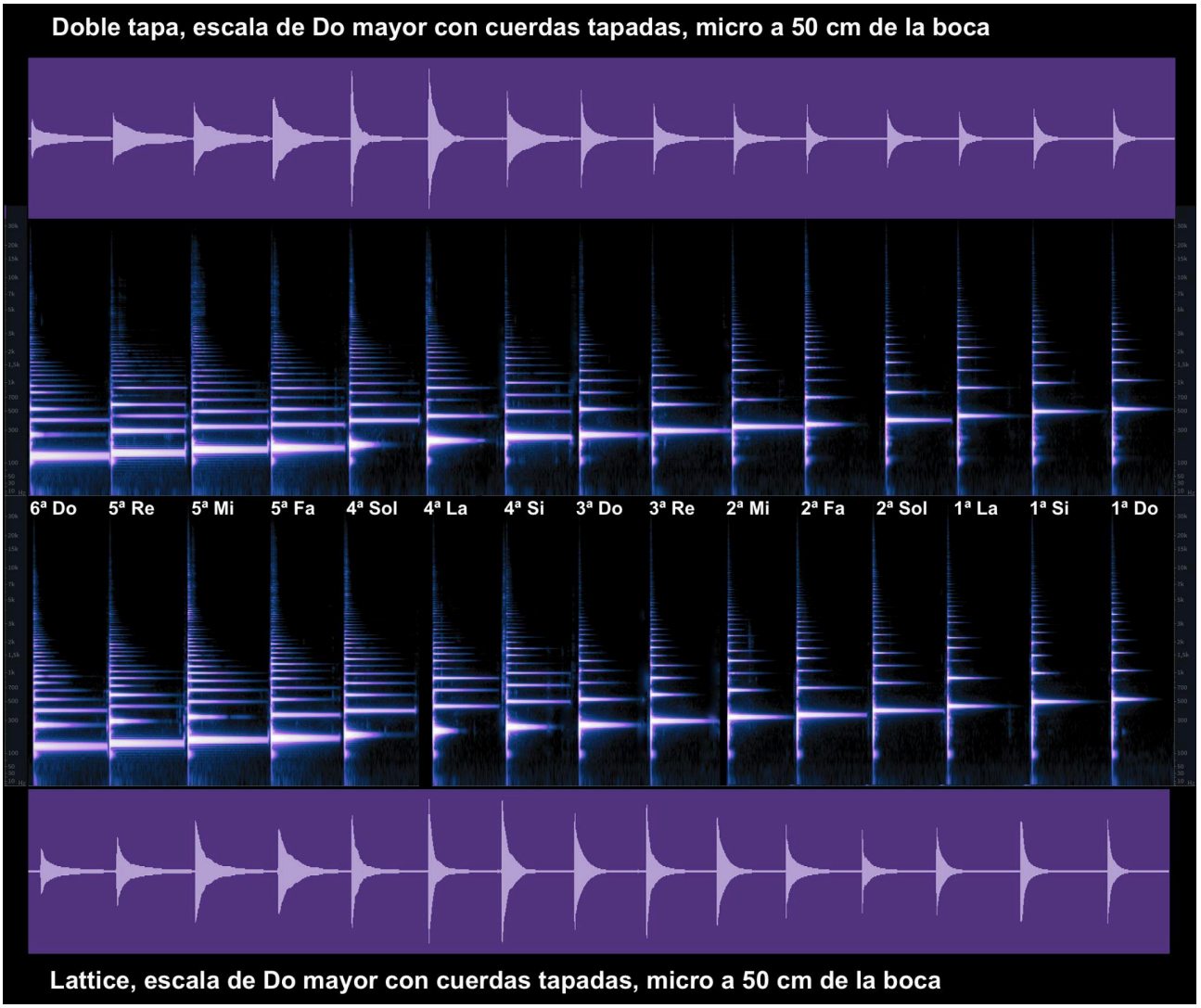
In the previous image and the image on the left, we can appreciate the behavior of the harmonics in the two instruments when playing a chord.

Not only is the amplification of mid-range frequencies noticeable in the Lattice Bracing model, presumably due to the use of carbon fiber on the Australian bracing, but also the greater definition of the harmonics in the Double Top model, while in the Lattice Bracing model they appear more blended, with less definition, as if they were 'out of focus.'

This latter aspect is very clearly noticeable in the image on the left.

In the image on the next page, we can observe a C major scale played in the 5th position.

From a timbral perspective, regarding harmonics, as we previously mentioned, the stability and balance of harmonics in the Double Top model offer a slightly better result. For example, while the C on the sixth string and its first harmonic (261.63 Hz) have little presence in the Double Top, in the Lattice Bracing, there's little presence in the C, D, and E. When we combine this with the previously mentioned fundamentals on the third and fourth strings in the Lattice Bracing, it's clear that the Double Top offers a slightly better balance.



In the following tests, we will observe the response of the two instruments when modifying the playing area: touche when the string is pressed over the end of the fretboard; boca when pressed over the beginning of the soundhole (the area of the soundhole closest to the bridge); and ponticello when pressed near the bridge.

If we analyze the evolution in each model of the harmonics as we move from touche to boca and ponticello, we will see that in the Double Top, this variation is slightly more pronounced. This means that the Double Top responds a bit better to changes in timbre, although both guitars respond well to these nuances.

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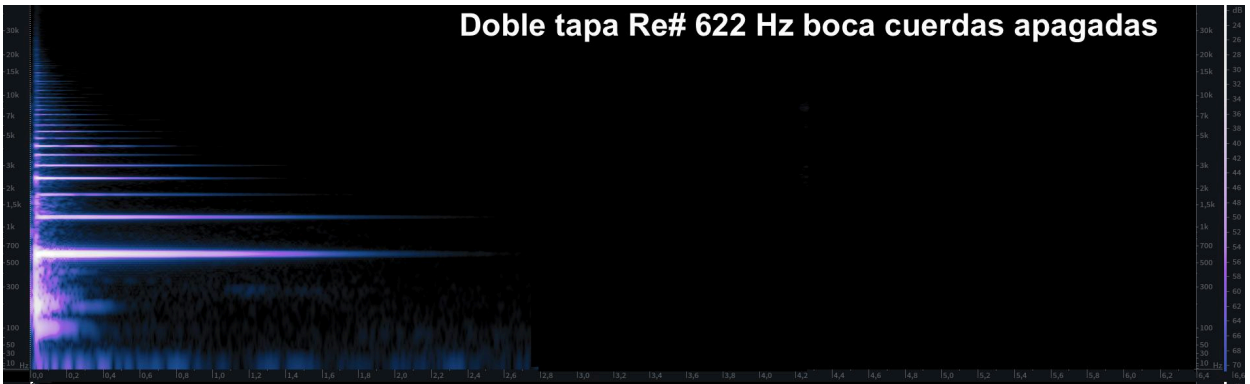

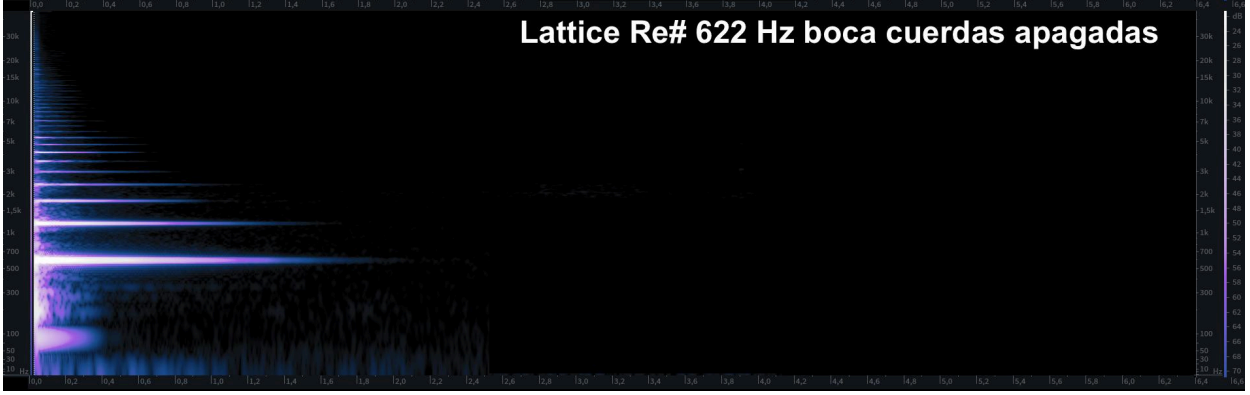

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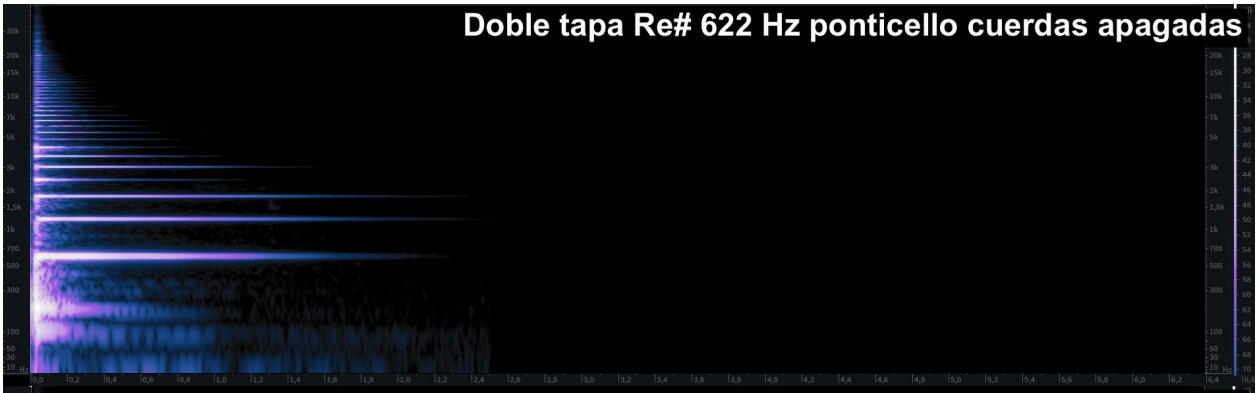

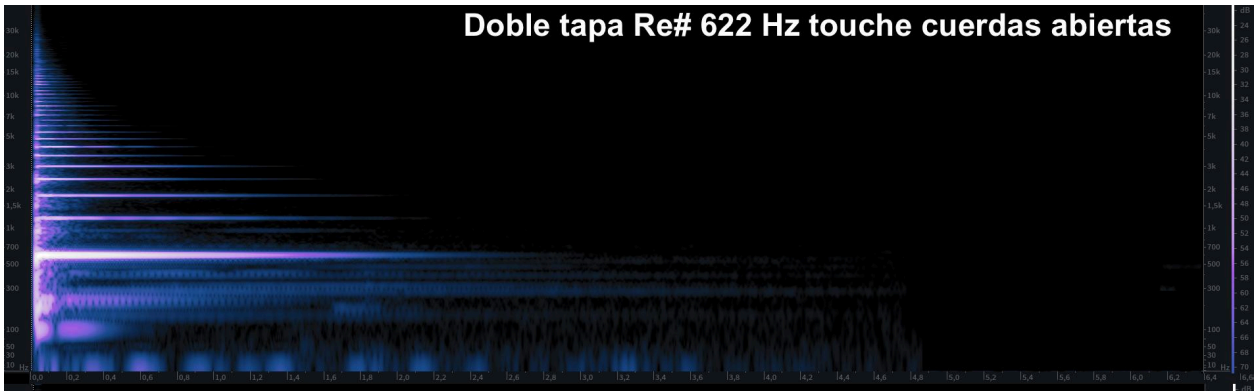

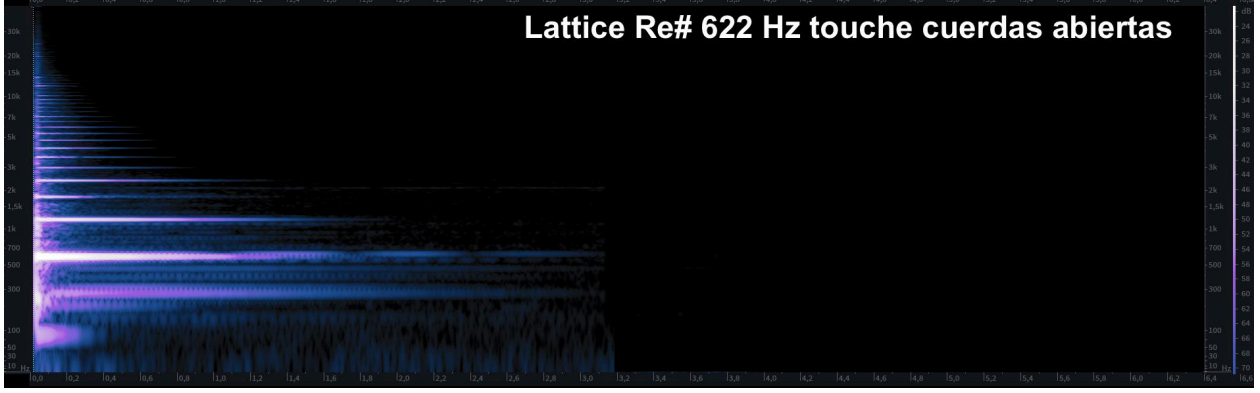

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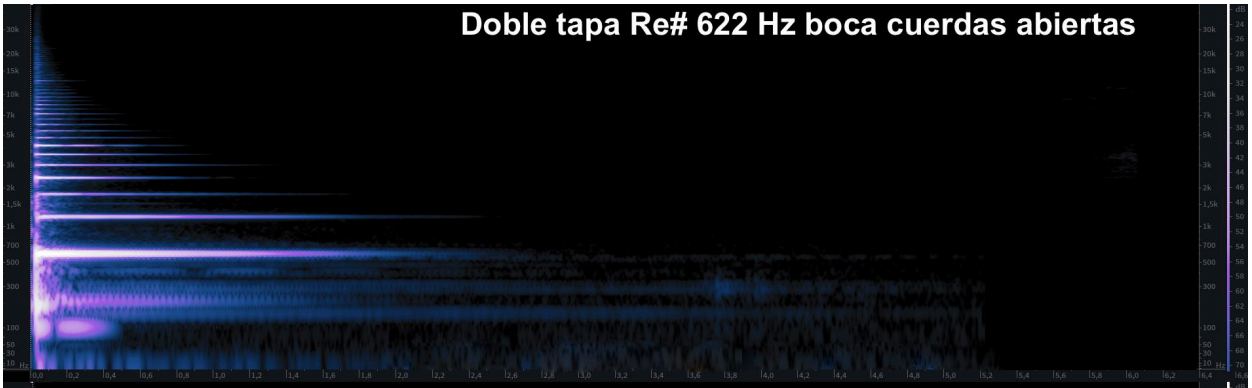

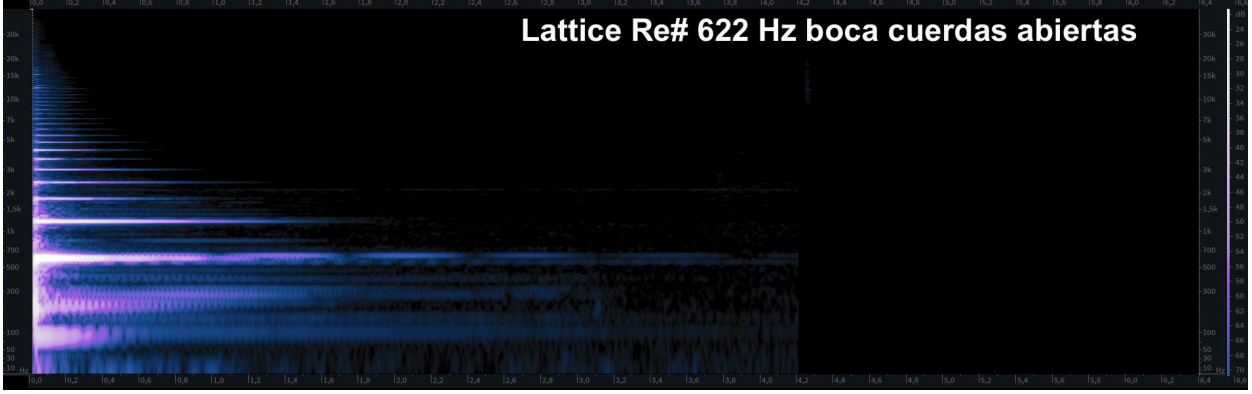

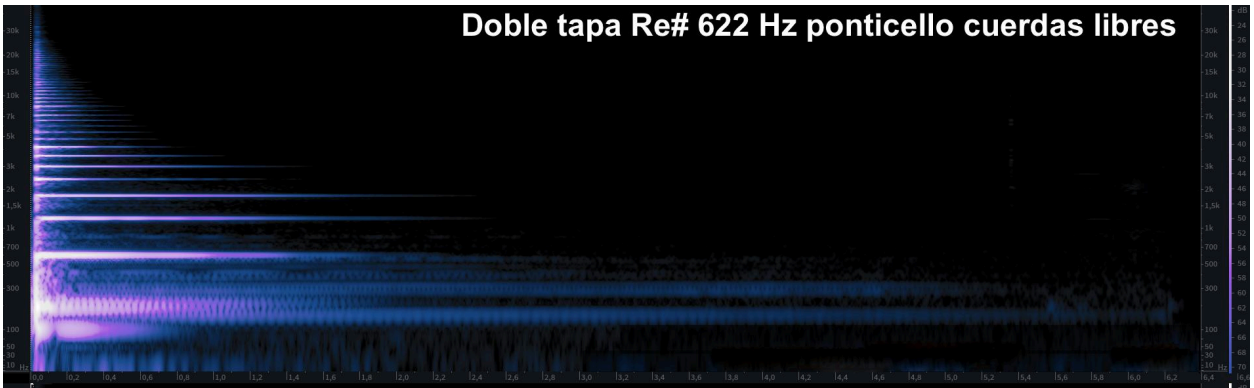

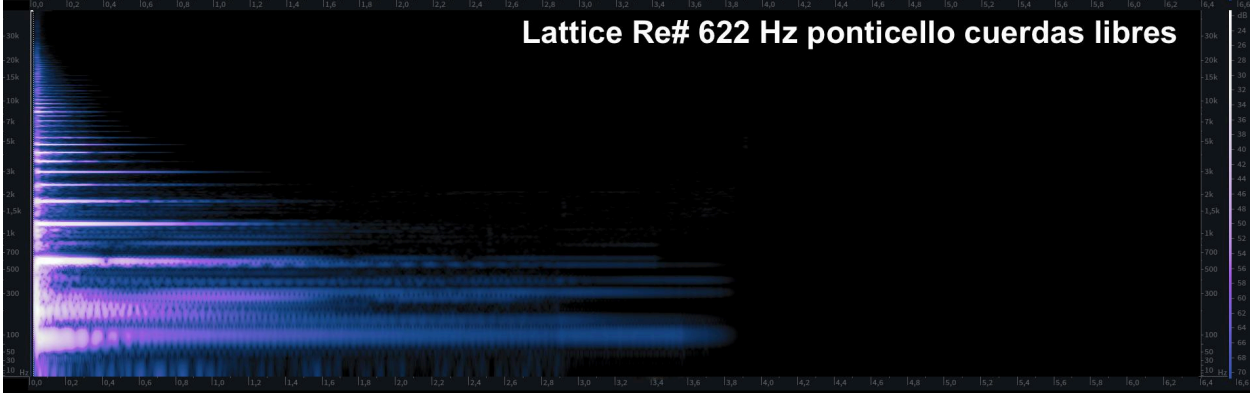

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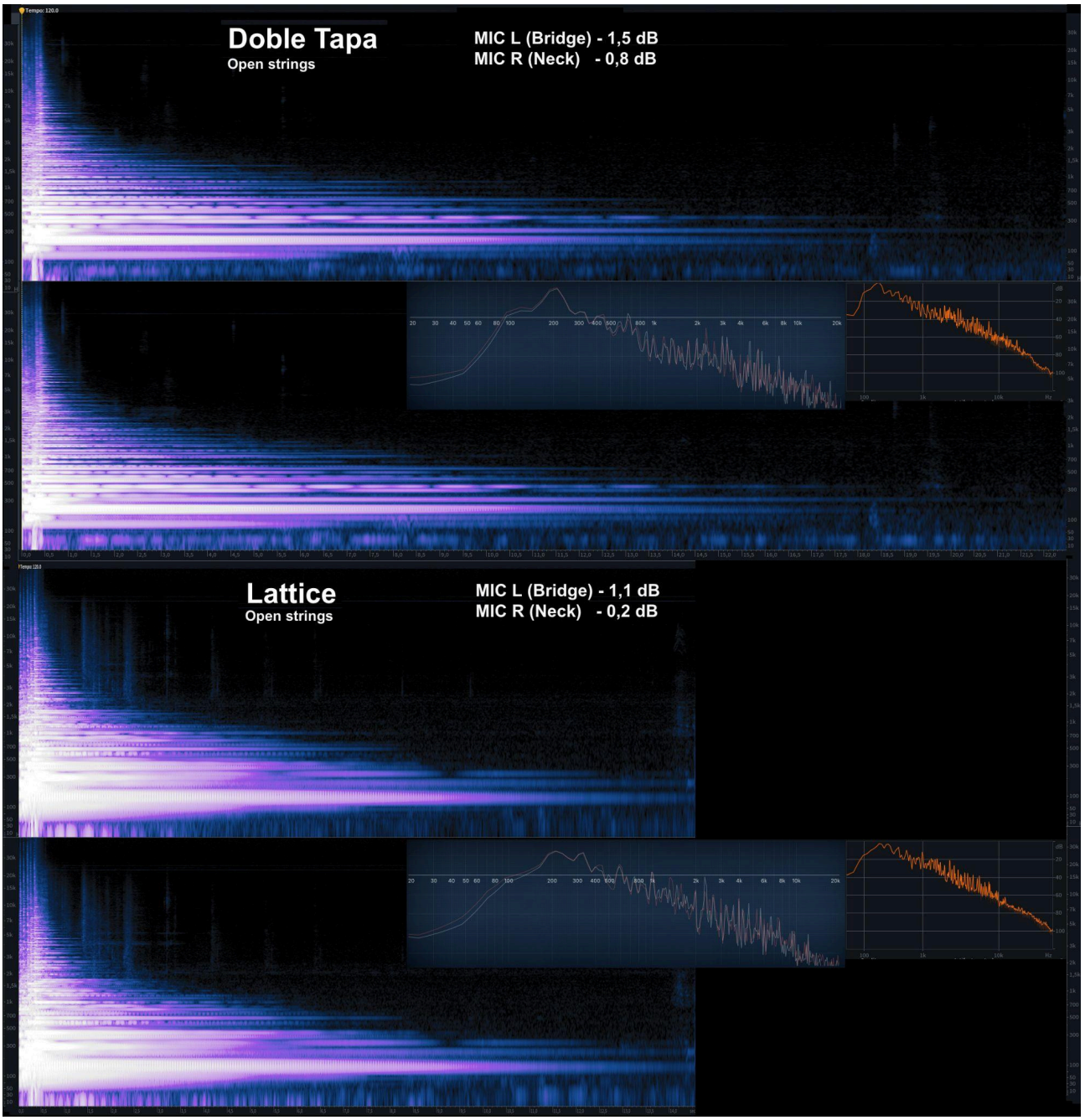
Sustain and Decay

Now, let's analyze the graphs from the perspective of sustain or decay of the sound, which refers to the resonance and the time the strings continue vibrating.



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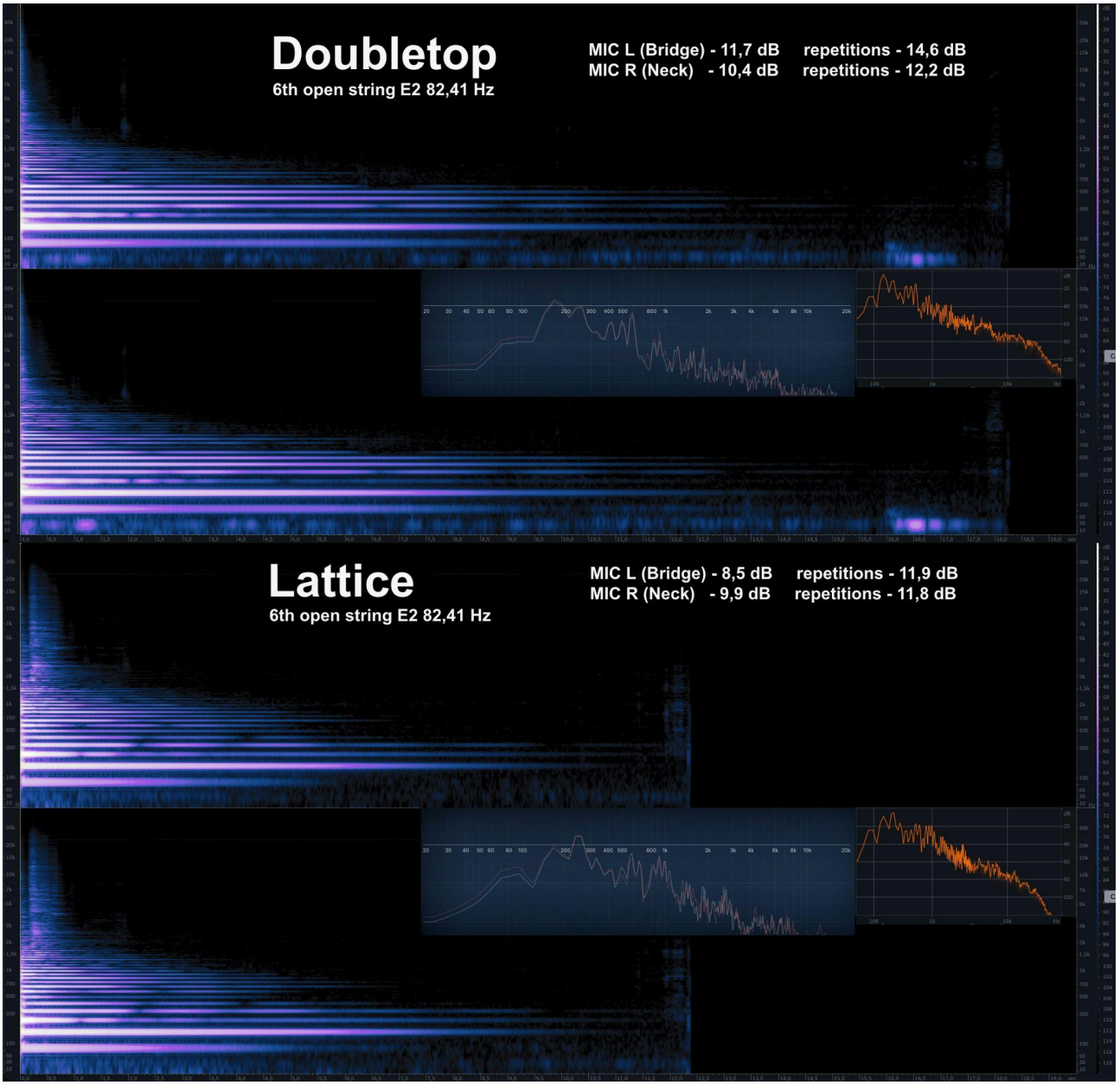
In the previous graph, two clear observations can be made: Firstly, the Double Top model offers greater sustain compared to the Lattice Bracing model, and secondly, the decay or reduction of harmonics is more pronounced in the Lattice.

In the following images, we will analyze this behavior for individual strings.



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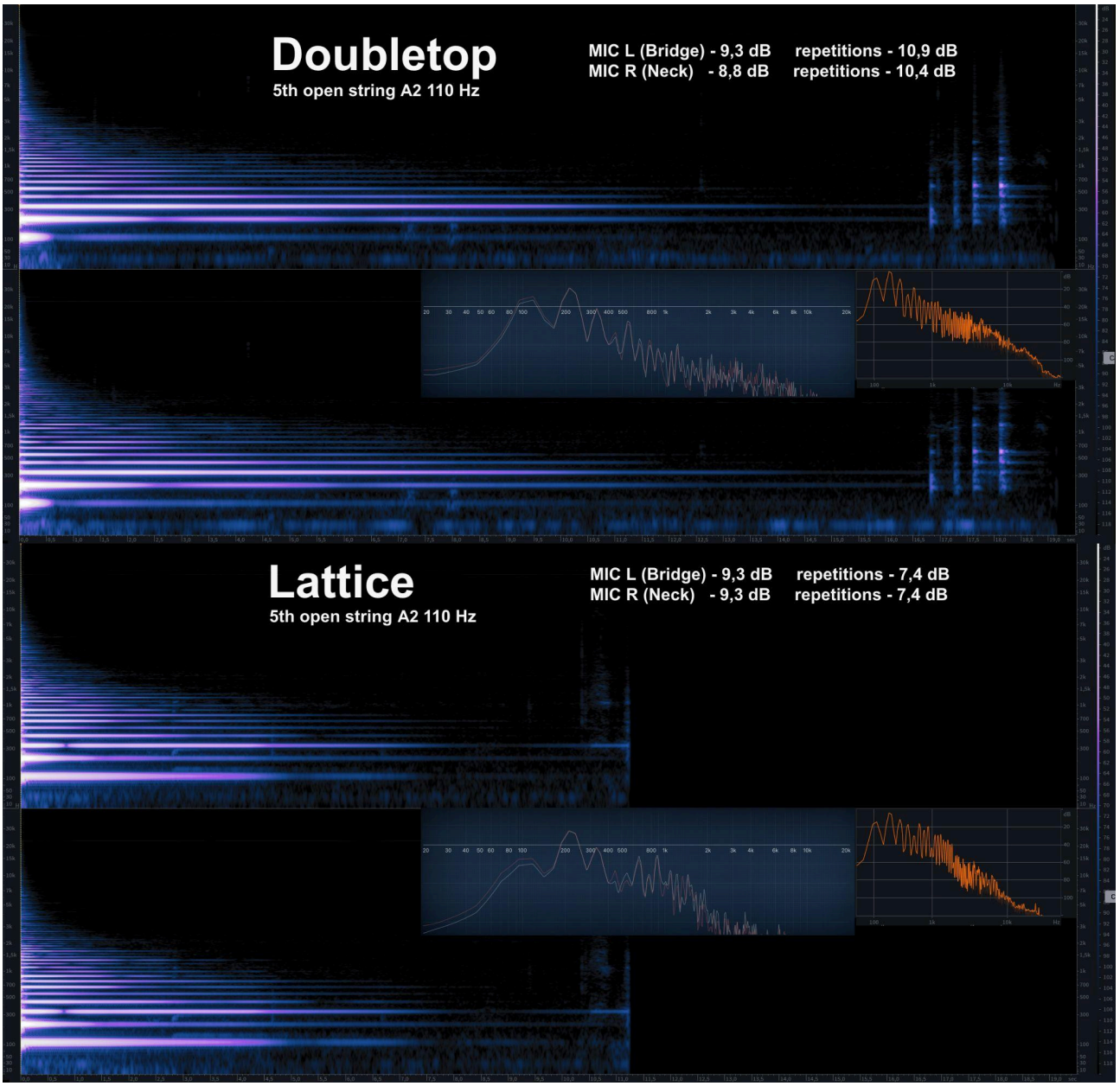

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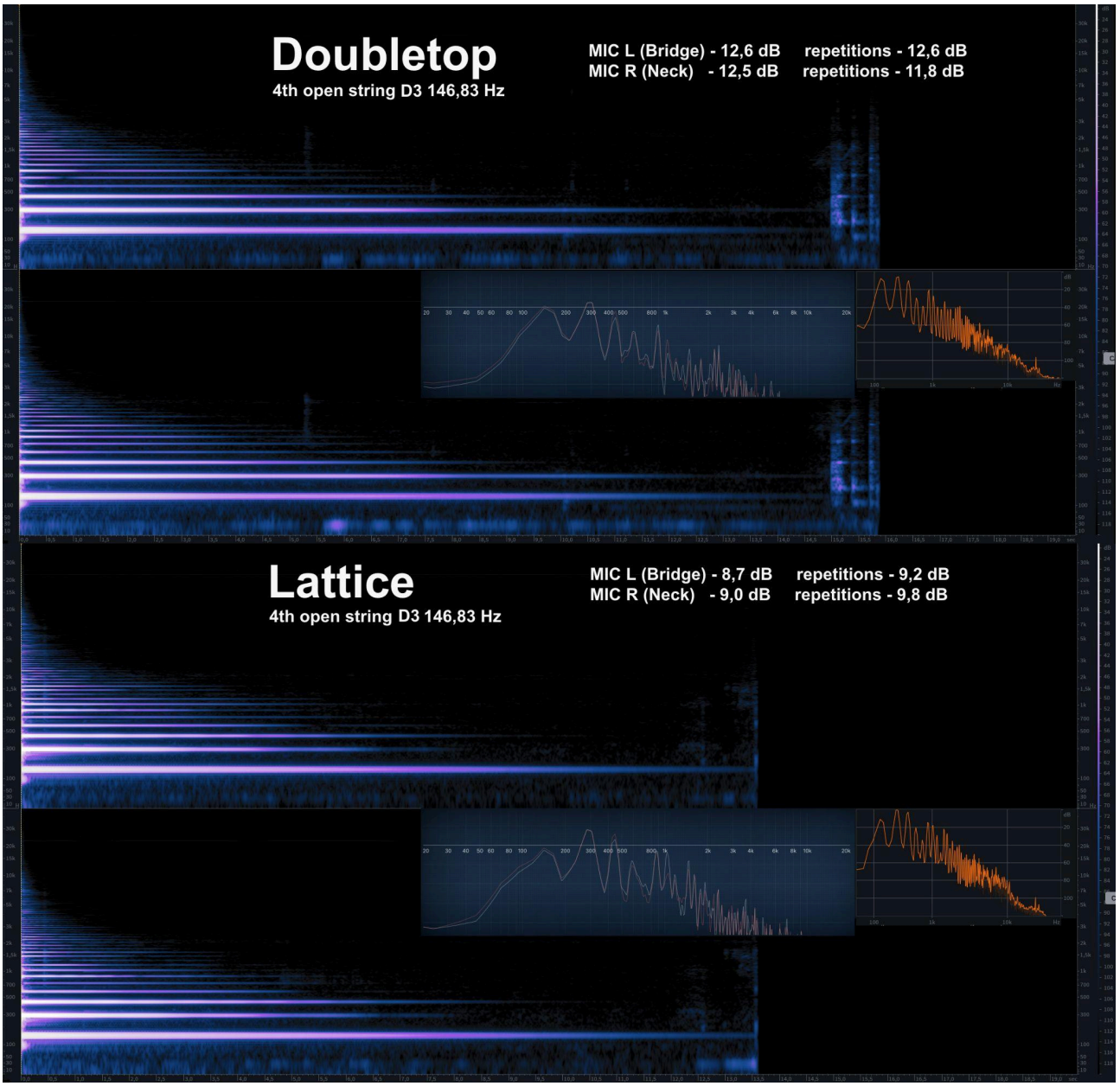

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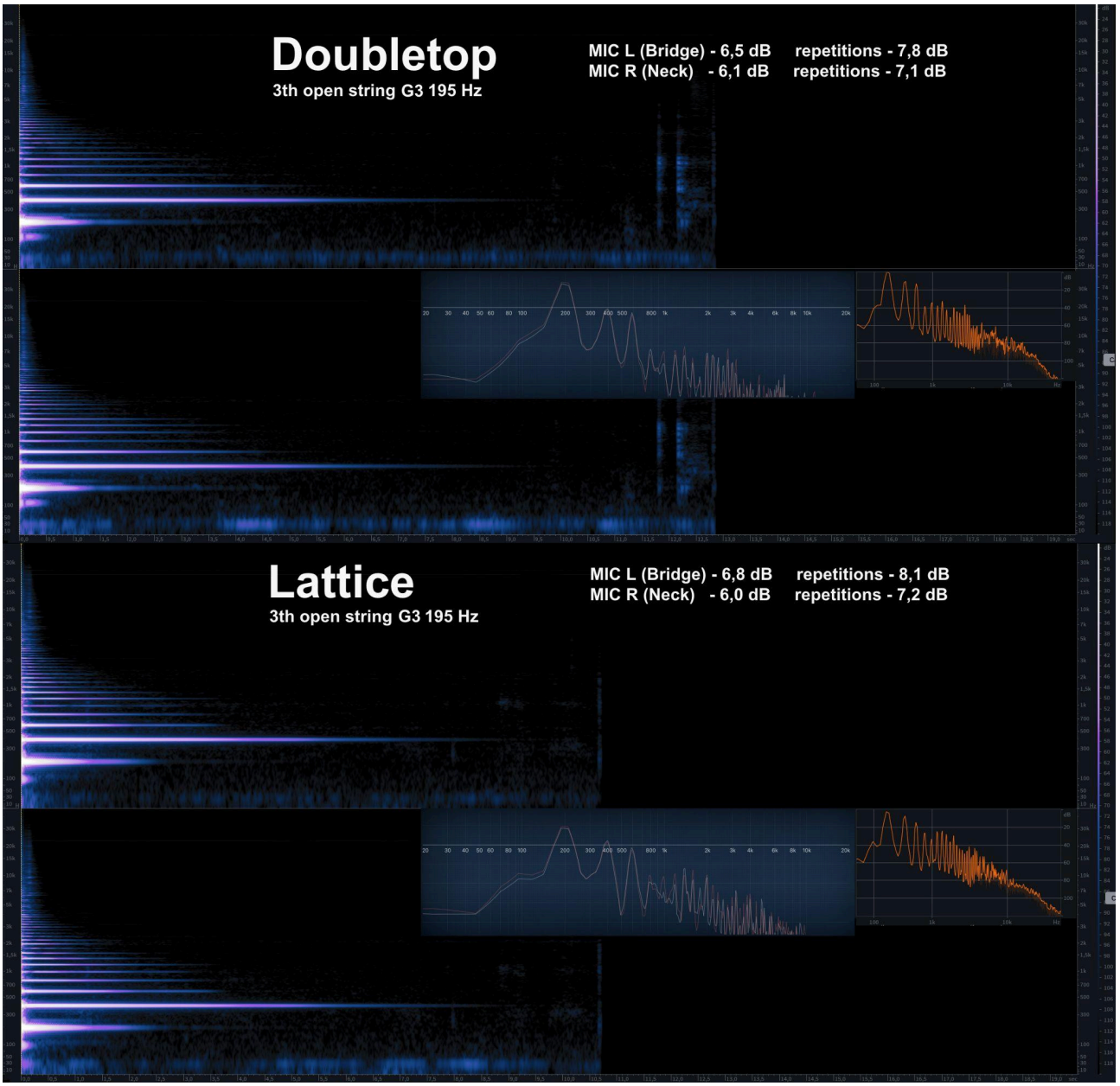

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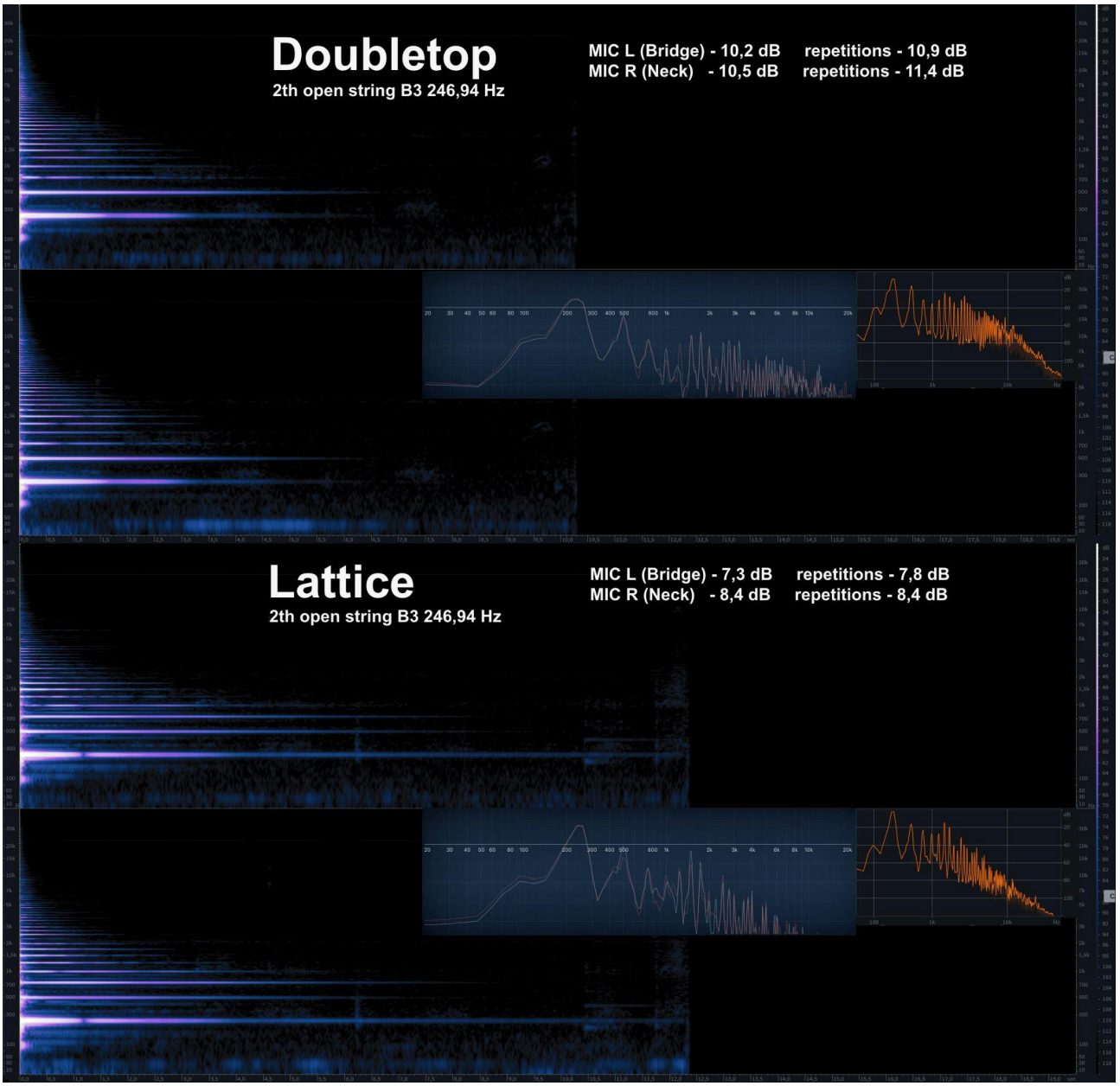

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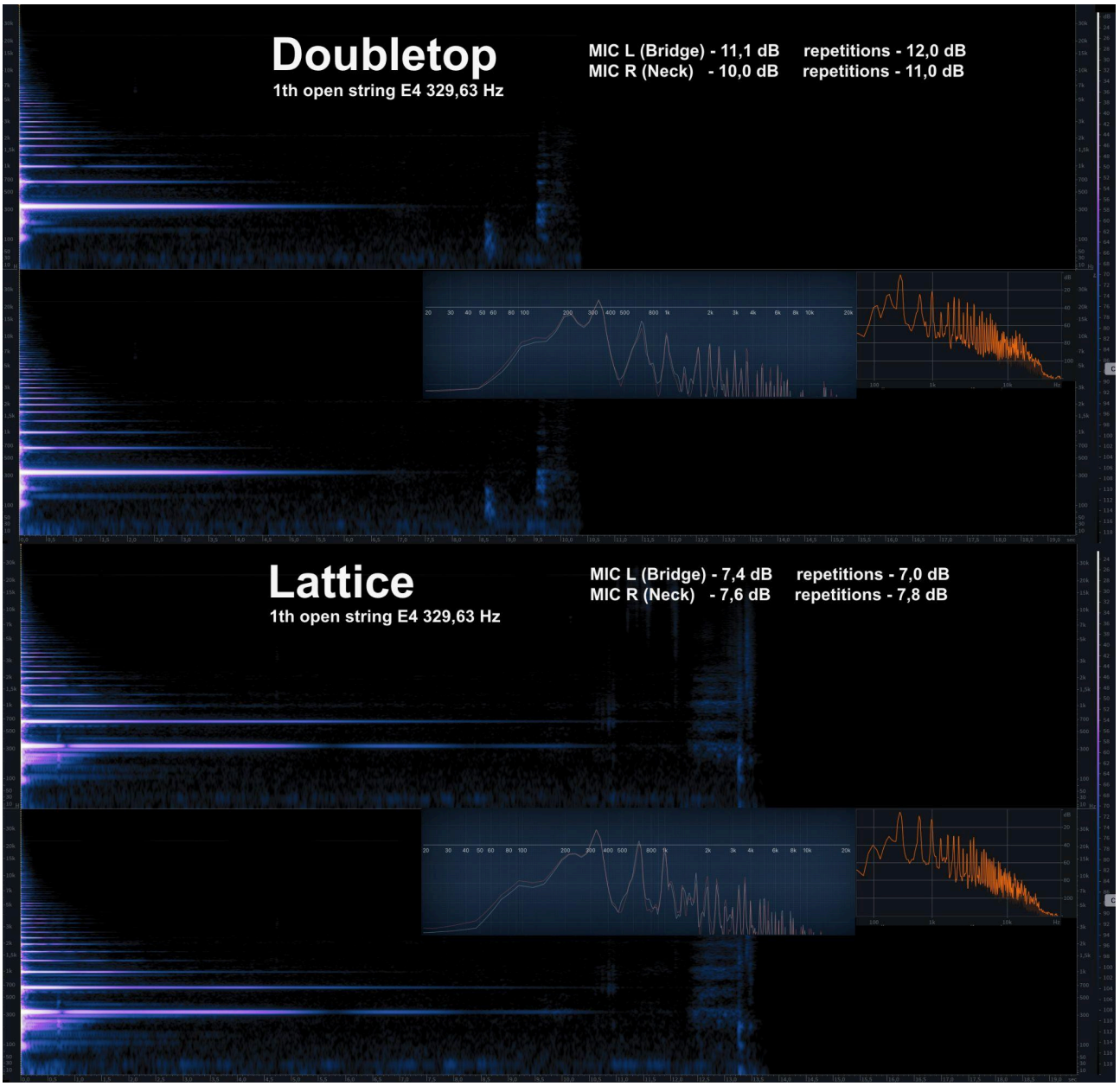

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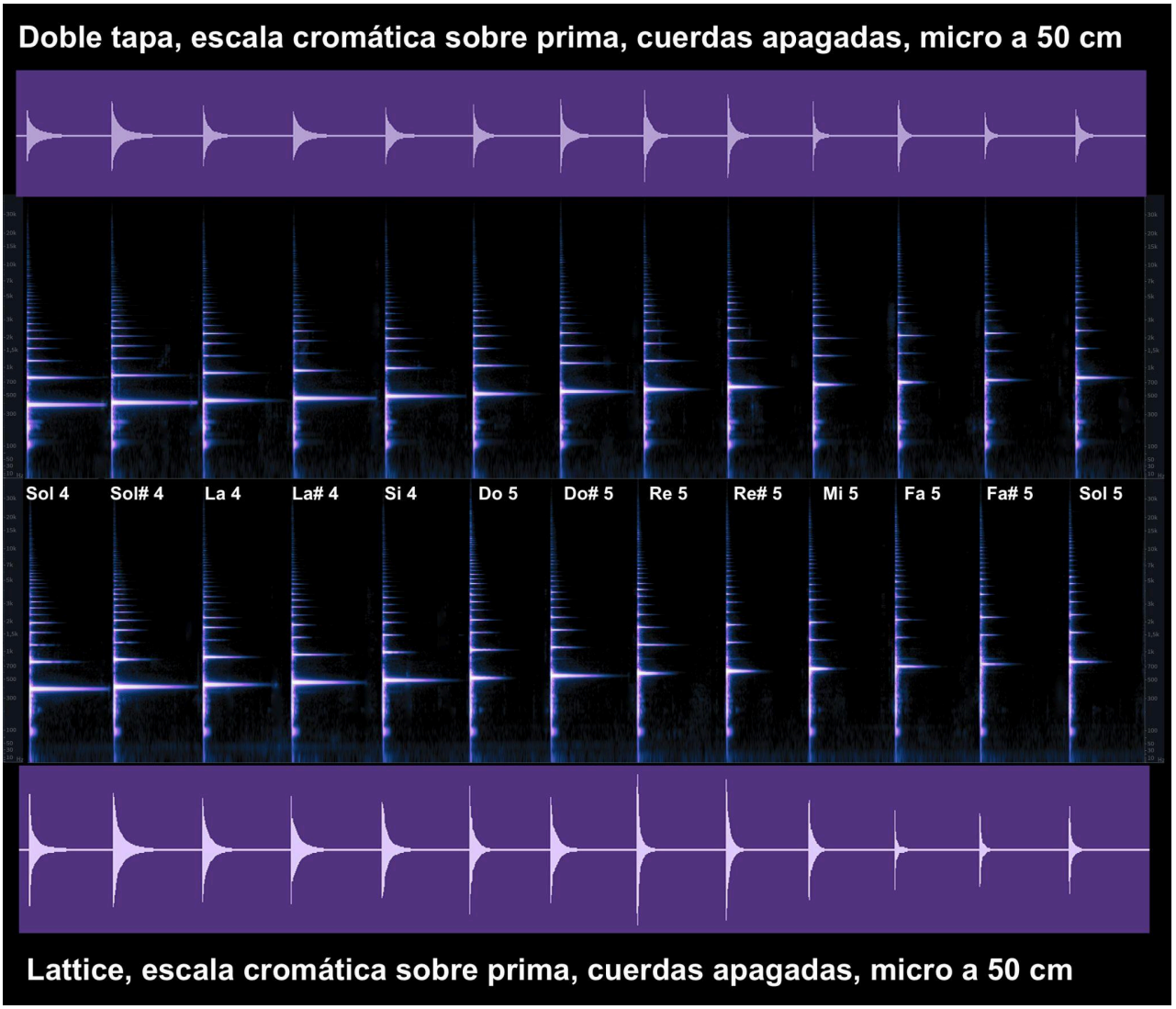
Analyzing the results of the six previous tests, it's evident that the Double Top model has greater sustain in the bass strings, while the Lattice Bracing model excels in the trebles. However, the decay in harmonics remains better in the Double Top across all strings.

It's also essential to consider a psychoacoustic effect: As it has been clearly demonstrated, the Lattice Bracing model has appreciably greater sound power than the Double Top. With higher initial volume, it's logical to assume that, under equal conditions, the resonance would last longer. In other words, if we play forte on the same instrument, the strings will vibrate for a longer time compared to pianissimo. However, despite emitting more power, the sound disappears sooner. Adding to that, the harmonics also vanish earlier in the Lattice. The final sensation is that, even though the treble strings may sustain longer in the Lattice, there's always a perception that the Double Top has much more sustain and longer harmonic decay, which some refer to as a 'piano-like sound.'

In the following graph, we'll observe the behavior of the two instruments over a chromatic scale on the first string, starting from G4 and reaching G5.

This image demonstrates how from A#4 onwards, the Double Top regains greater sustain than the Lattice, while also maintaining its harmonics. It's also evident that the Lattice continues to emit much more volume than the Double Top.

It's also worth noting that on the first string, the drum effect seems slightly more pronounced in the Double Top model than in the Lattice Bracing. Very little, in reality. But on the rest of the strings, as we observed earlier, it's the Lattice Bracing that has a slightly greater presence of this effect.



Sensations and Summary

This musical acoustic study was conducted using only one guitar of each model, so the results are based on these two instruments. If the study were conducted with ten guitars of each model, it would likely yield minor variations, but not significantly different ones.

The aim is to identify general trends between two models that use distinct construction systems in their soundboards, which give them different personalities.

Both models are, in appearance and aesthetics, practically identical.

In terms of weight, both guitars weigh around 1.8 kilograms, with the Double Top being slightly heavier.

Regarding action, they are essentially identical, although the neck thickness of the Lattice Bracing model is thinner, making it more comfortable to play.

The Lattice Bracing model surprises and impresses with its quick response to musical gestures, its ability to nuance, as its dynamic range is pronounced, as well as its response to legatos, vibratos, etc.

On the other hand, the Double Top model seems to require a bit more effort from the player to react to musical nuances, but in return offers more tonal changes.

Comparatively speaking, with respect to other guitars, both are extremely comfortable and versatile, but the Lattice Bracing gives the impression of requiring less effort. This is likely because the soundboard, being extremely thin, responds like the skin of a drum to the slightest gesture.

In terms of volume, the Lattice Bracing has emitted up to 5 decibels more in some of the tests compared to the Double Top. However, it should be noted that the Double Top emits more volume than any conventional guitar.

The tone of the Double Top is more defined, more transparent, more balanced, allowing each string to be better understood in chords and arpeggios. The tone of the Lattice Bracing is more nasal and has less brightness, which makes it blend better by losing presence in the high frequencies and enhancing the midrange.

From the perspective of sustain in the fundamentals and decay in the harmonics, the Double Top performs much better. Only in the trebles does the Lattice Bracing slightly improve in the fundamental.

In summary, these are two first-class guitars with distinct characters. Depending on the style and needs of the instrumentalist, one may be more preferable than the other. But for

someone who wants to tackle different styles, the best option is to have both models, as each offers characteristics that the other cannot provide.

You can check out two videos, one more musical and the other more technical, to hear the differences and draw your own conclusions. Here are the links to YouTube:

- Double Top vs Lattice Bracing Fernando Mazza's guitar / Enrique Mateu (producer and guitarist) https://youtu.be/4m7t5VJTFnA
- Double Top guitar vs Lattice Bracing guitar technical video. Fernando Mazza (luthier) / Enrique Mateu (producer and guitarist) https://youtu.be/lKe-aEtE1XA

Study Specifications

The study was conducted using DPA 4011A microphones, Millennia HV-3C preamps, Apogee Ensemble converters, Logic X Pro software, and iZotope applications.

The microphones were placed in the specified areas for each test. For all measurements, the samples were repeated up to a dozen times to minimize human error.

Study conducted by guitarist and music producer Enrique Mateu at his Estudio Paraíso between February and April 2024.