

# Music of natural law

(Music controlled mathematically by Golden Ratio)

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## Notation for performance

In this work, the tuning pitches of strings are originally decided by calculated with Golden Ratio, which makes the special effect on harmony different from normal tuning. The music begins with niente by viola and after variations with harmonic and rhythmical expression, the music reaches the climax in the time divided by the golden ratio.

Golden ratio is a special number, 1.618 (approximately 5 of 8th), which appears often in nature, geometry, art, architecture and other areas. The pitches are calculated by  $f_{n+1} = G * f_n$  (here  $G = 1.618$ ) repeatedly, and is divided if the multiplied pitch becomes over twice of base pitch  $f_0$ . From this method, the obtained scale of golden ratio is shown in Fig.1 and Table 1.

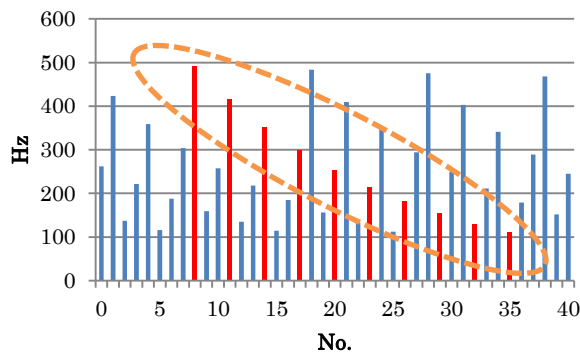


Fig.1 Pitch pattern calculated by Golden ratio and selection for scale

Table 1. Comparison of pitches by golden ratio and equal temperament

Golden Ratio div by 5		Equal temperament	
No.	Pitch(Hz)	Name	Pitch(Hz)
1	440	A	440
2	489.8	A#	466.1
3	504.4	H	493.8
4	519.6	C	523.2
5	595.6	C#	554.3
6	613.4	D	587.3
7	703	D#	622.2
8	724.2	E	659.2
9	829.8	F	698.4
10	854.8	F#	739.9
-	-	G	783.9
-	-	G#	830.6

The tuning pitches of each strings by the golden ratio based on A 440 Hz are selected as follows,

- 1st Violin I : 702Hz (near F), II: 440 Hz(A), III: 297 Hz (near D), IV: 213 Hz(between G#-A)
- 2nd Violin I : 612Hz (near D#), II: 440 Hz(A), III: 260 Hz (near C), IV: 181 Hz(near F#)
- Viola I : 440Hz (A), II: 297 Hz(near D), III: 207 Hz (near G#), IV: 122 Hz(near H)
- Cello I : 220Hz (A), II: 153 Hz(near D#), III: 91 Hz (near F#), IV: 64 Hz(between H-C)

Players can tune these strings by the application software installed in Android mobile phone or iPhone etc.

In Fig.2, the pitches of open and natural by shift change harmonics in this work is shown.


The figure displays musical notation for four instruments: 1st Violin, 2nd Violin, Viola, and Cello. Each instrument part is shown in four positions, labeled I, II, III, and IV. The notation includes notes with stems and flags, indicating specific pitch shifts. The 1st and 2nd Violin parts are in treble clef, while the Viola and Cello parts are in bass clef. The word 'open' is written below the first note of each position for the Violin and Viola parts. The notes are marked with sharp signs (#) and natural signs (♮) to indicate the specific pitch changes.

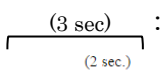
Fig.2 Pitch shift change of open and natural harmonics

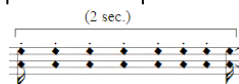
The other special notes in this work are following,

- [0'20"] on bars : The time from the start as the standard performance time (minute/second).

- nail-pizzicato : pizzicato by the face of nail of a finger,

-  : wavy dynamics mark. Player performs in the dynamics according to the wave's shape.

-  : play during noted seconds,

-  : play unevenly during noted seconds,

- Bar 12 of cello. Player has the bow upside down as shown in the right figure and performs under side of both I and IV strings at the same time.

