

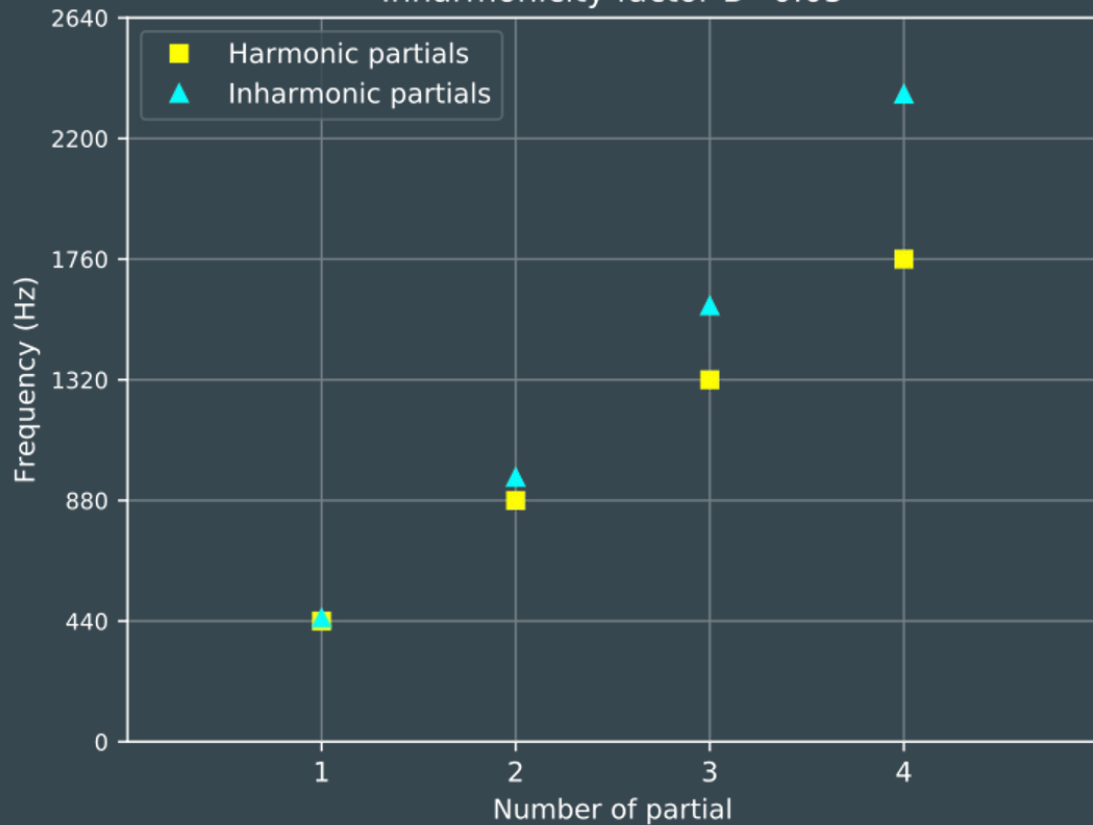
Inharmonicity in the timbre of string instruments



Néstor Nápoles López

Inharmonicity

Fundamental frequency of 440Hz
Inharmonicity factor $B=0.05$



What is Inharmonicity

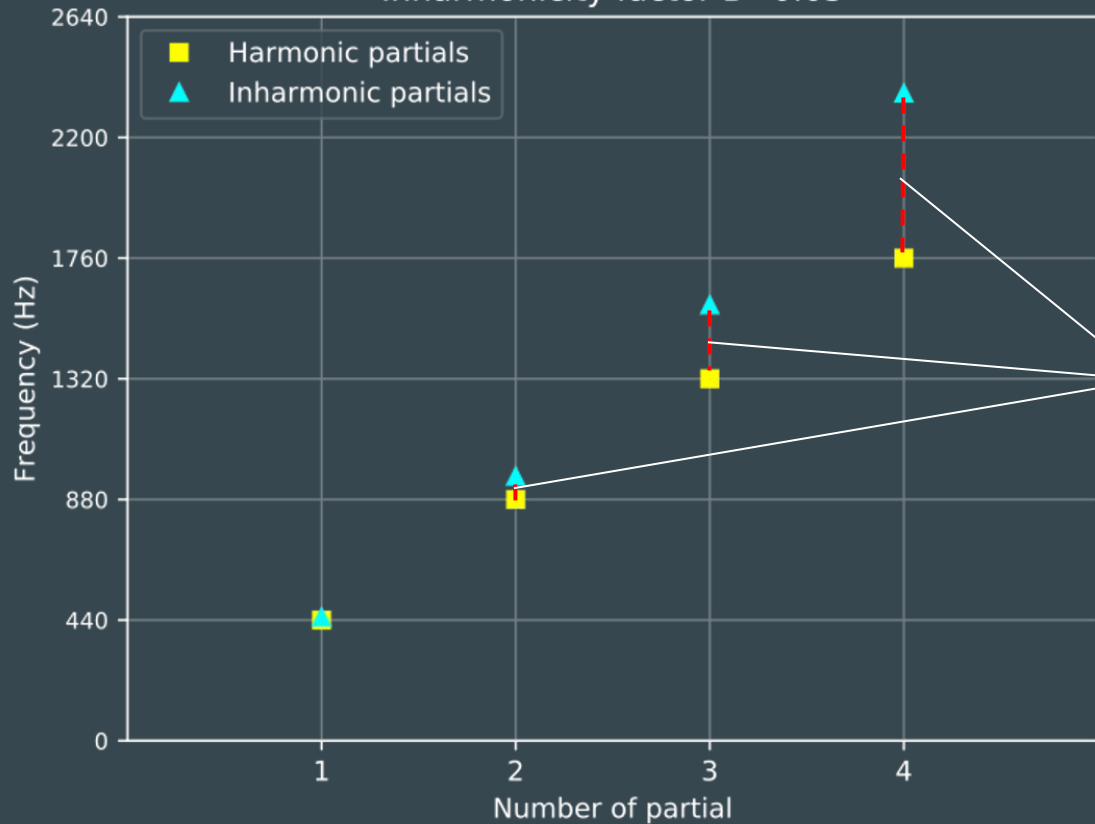
How much the partials depart from a multiple of the fundamental frequency

Not necessarily unpleasant

Sometimes associated with adding **warmth** to the sound

Inharmonicity

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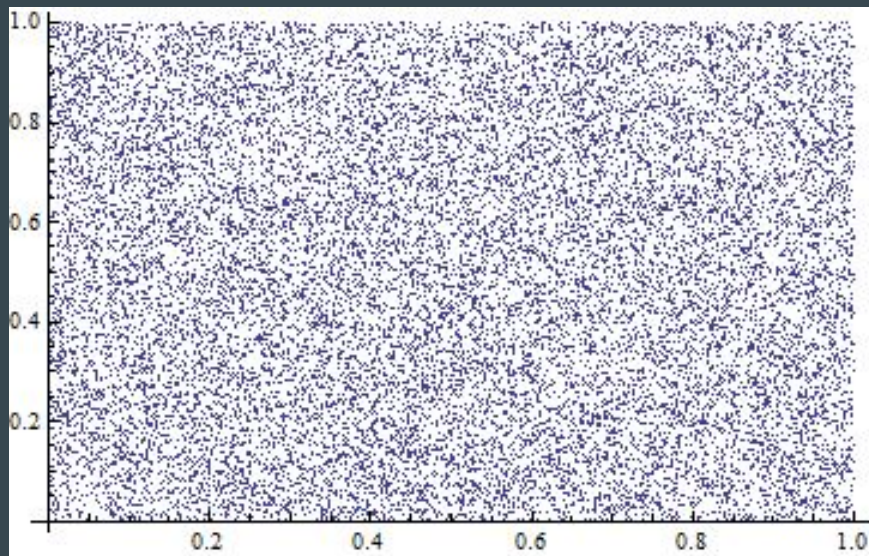


Inharmonicity

Inharmonicity



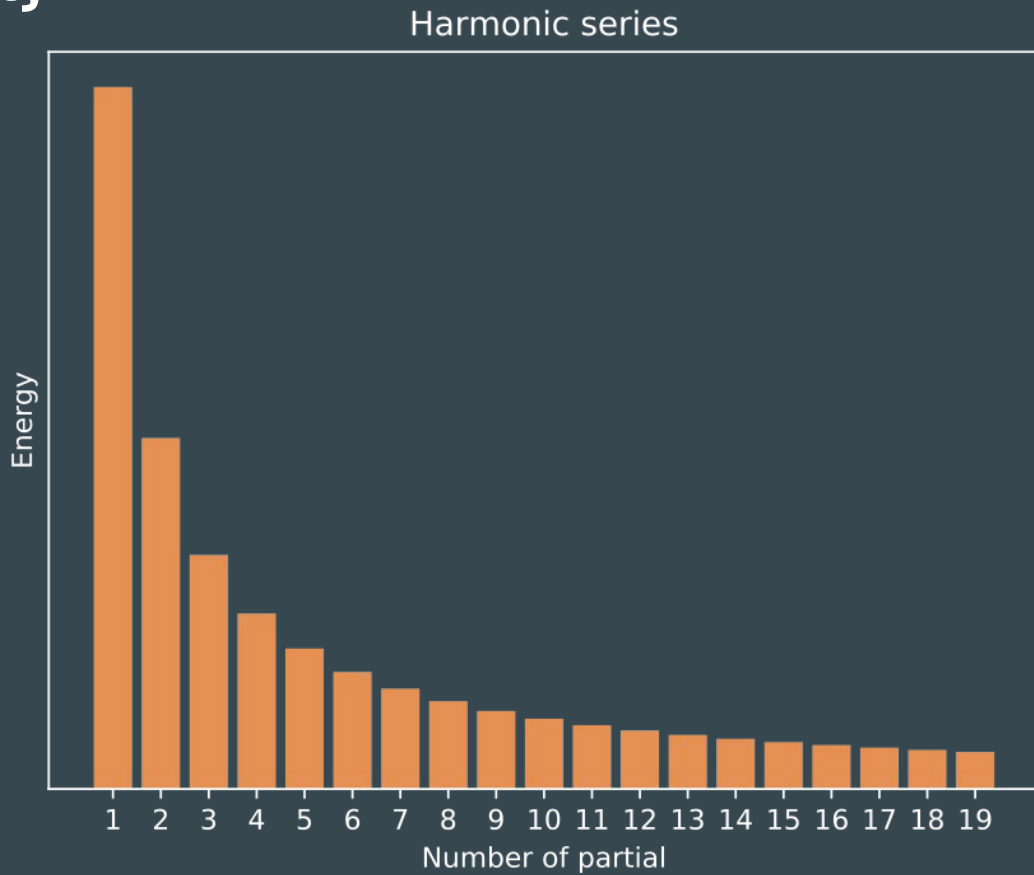
Inharmonicity



Inharmonicity



Inharmonicity



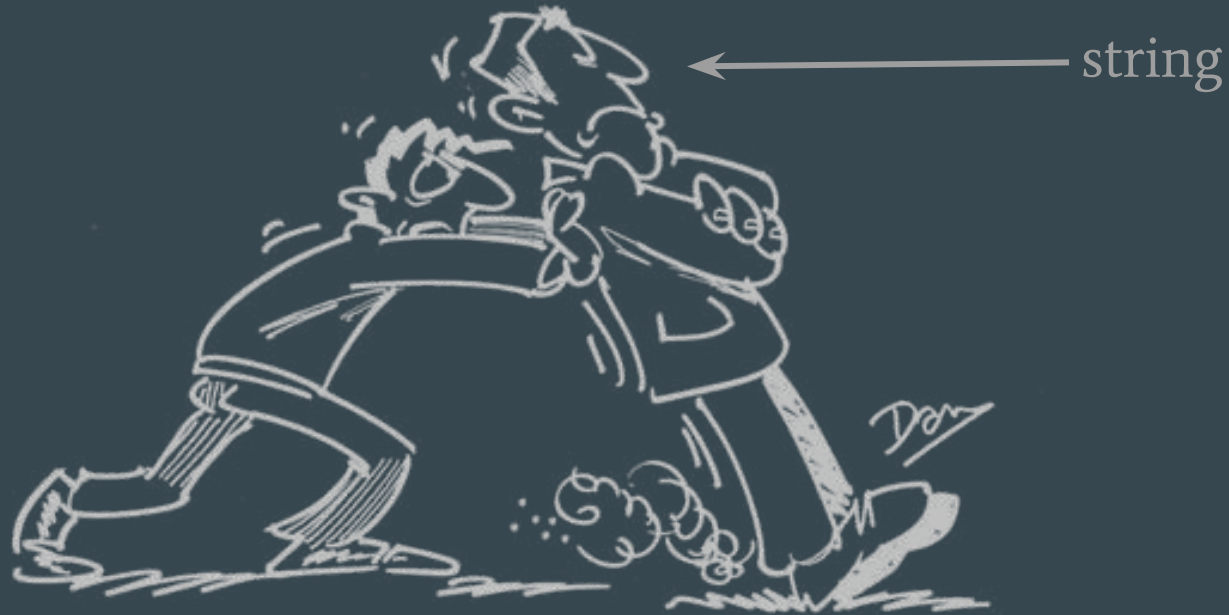
Papers reviewed

Focusing on strings

- Järveläinen, H., Välimäki, V., & Karjalainen, M. (2001). Audibility of the timbral effects of inharmonicity in stringed instrument tones. *Acoustics Research Letters Online*, 2(3), 79-84.
- Järveläinen, H., & Karjalainen, M. (2005). Importance of inharmonicity in the acoustic Guitar. *ICMC*.

In the case of string instruments

Inharmonicity is caused by *stiffness* of real strings



The only formula of this presentation

$$f_n = n f_0 \sqrt{1 + B n^2}$$

Calculates the frequency of a partial
where ***B*** represents the inharmonicity factor

Järveläinen, 2001

Present a complex tone with exact harmonic partials

and another almost identical with inharmonic partials

Find the threshold where people hear the difference

Järveläinen, 2001

The lower the tone, the easier to hear inharmonicity

f_0	B at mean threshold
A_1	0.00000014
E_2	0.00000024
A_3	0.000010
G_4	0.000018
$C\#_6$	0.00021

Järveläinen, 2005

Measure the inharmonicity coefficients

from recorded guitar sounds

Compare to the audibility threshold of inharmonicity

References

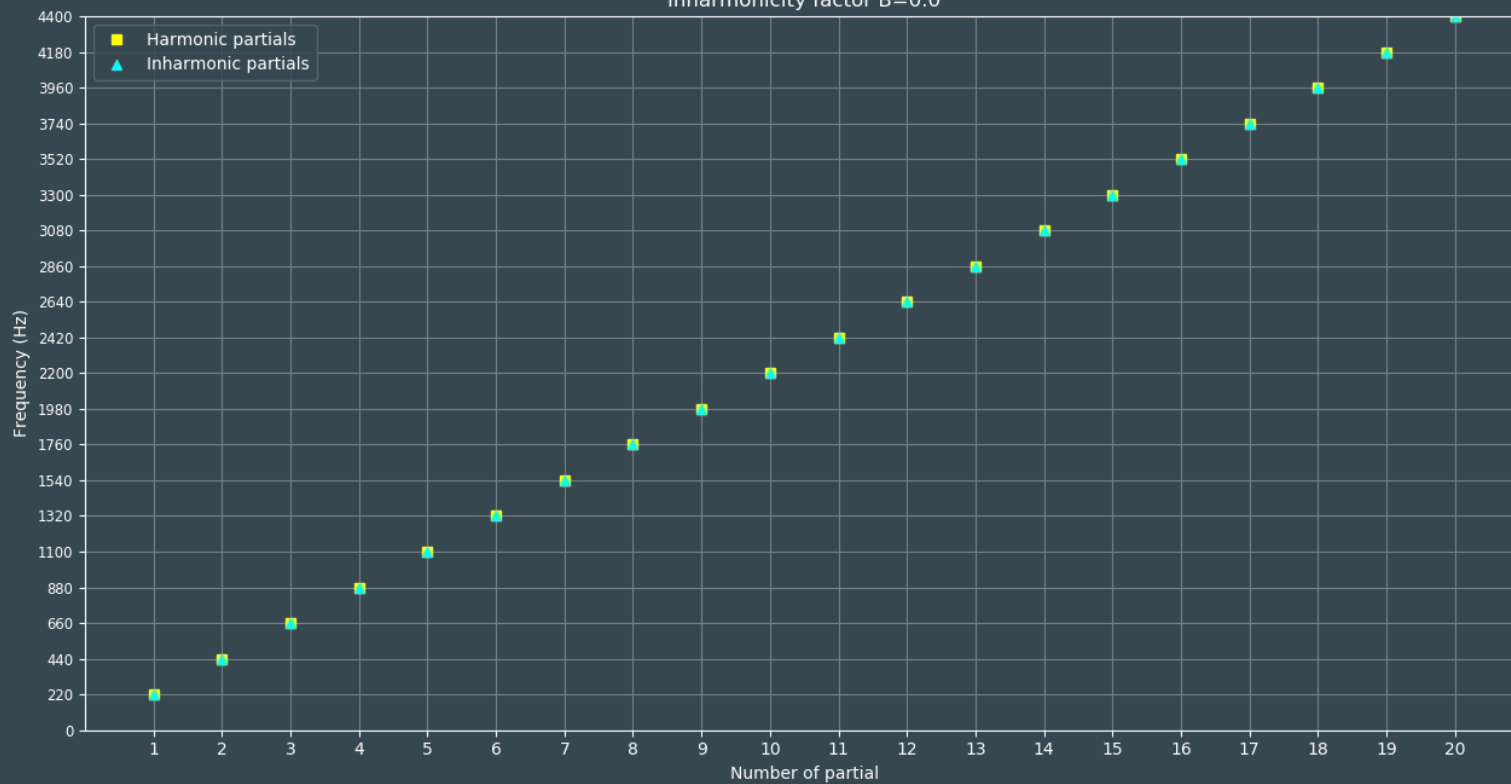
Guitar strings are always above the hearing threshold of inharmonicity

String, fret	f_0 [Hz]	B
String 1, fret 1	349	0.000047
String 1, fret 12	659	0.00017
String 3, fret 1	207	0.00015
String 3, fret 12	392	0.00052
String 6, fret 1	87	0.0000205
String 6, fret 12	165	0.00007

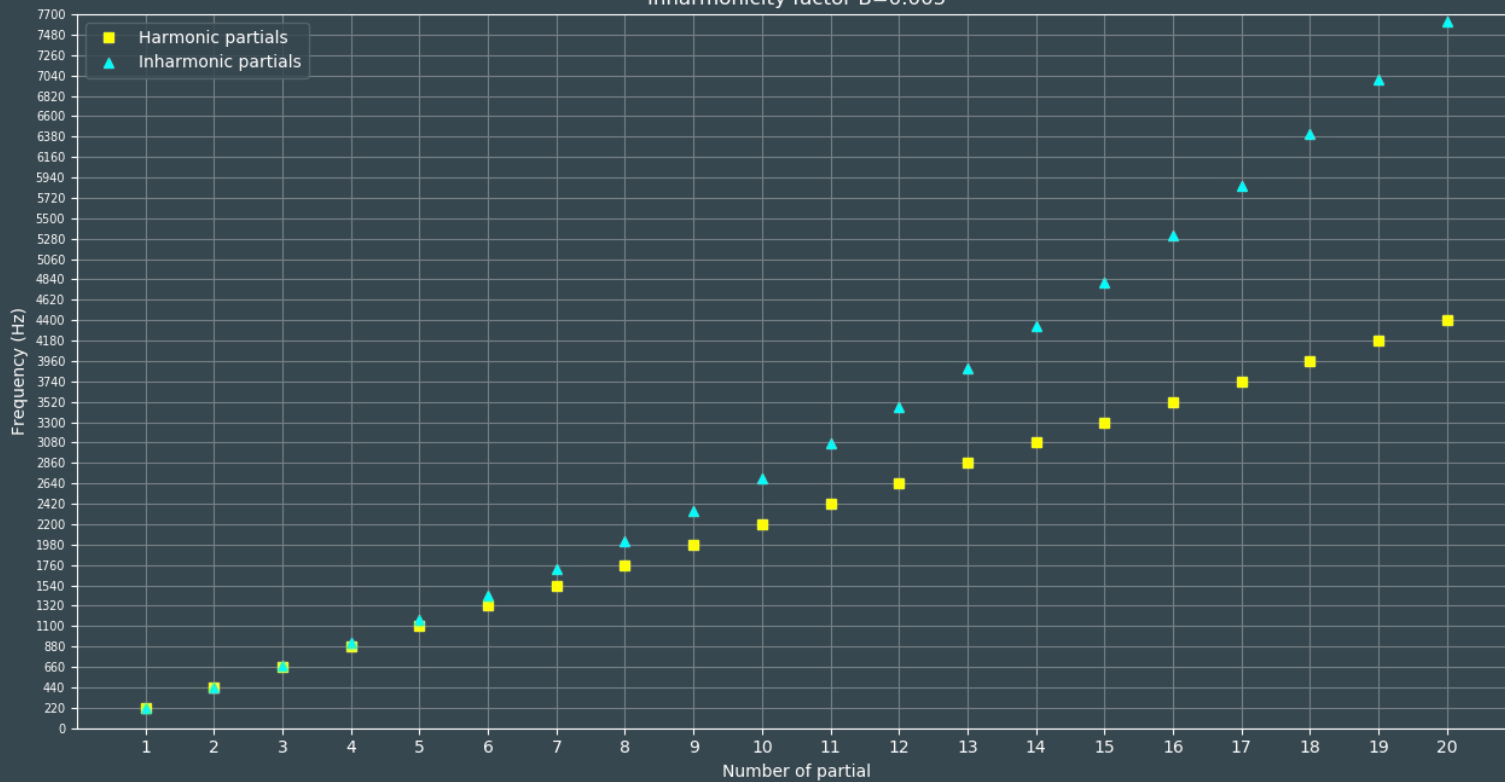
Demos

Fragment of music with different degrees of inharmonicity

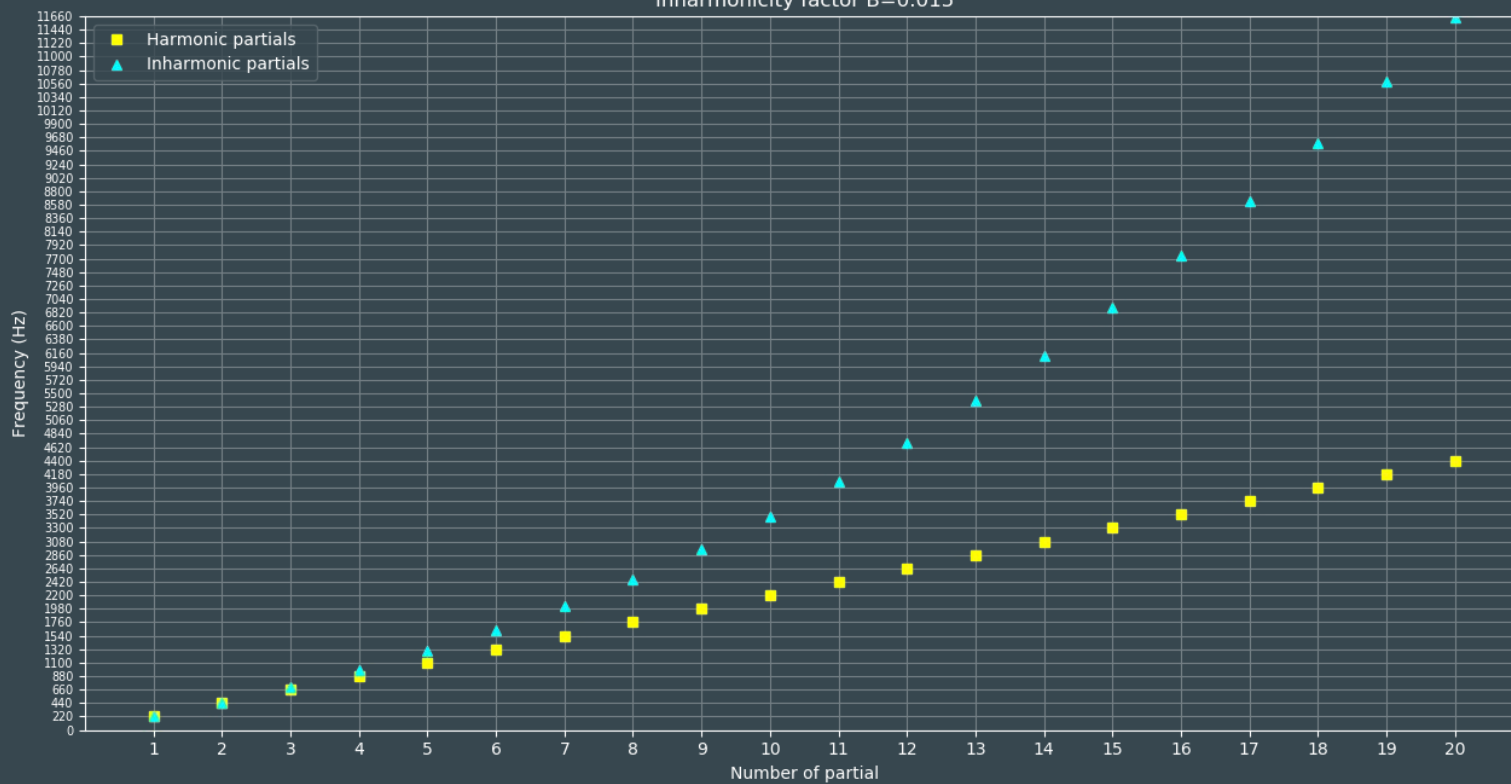
Fundamental frequency of 220Hz
Inharmonicity factor B=0.0



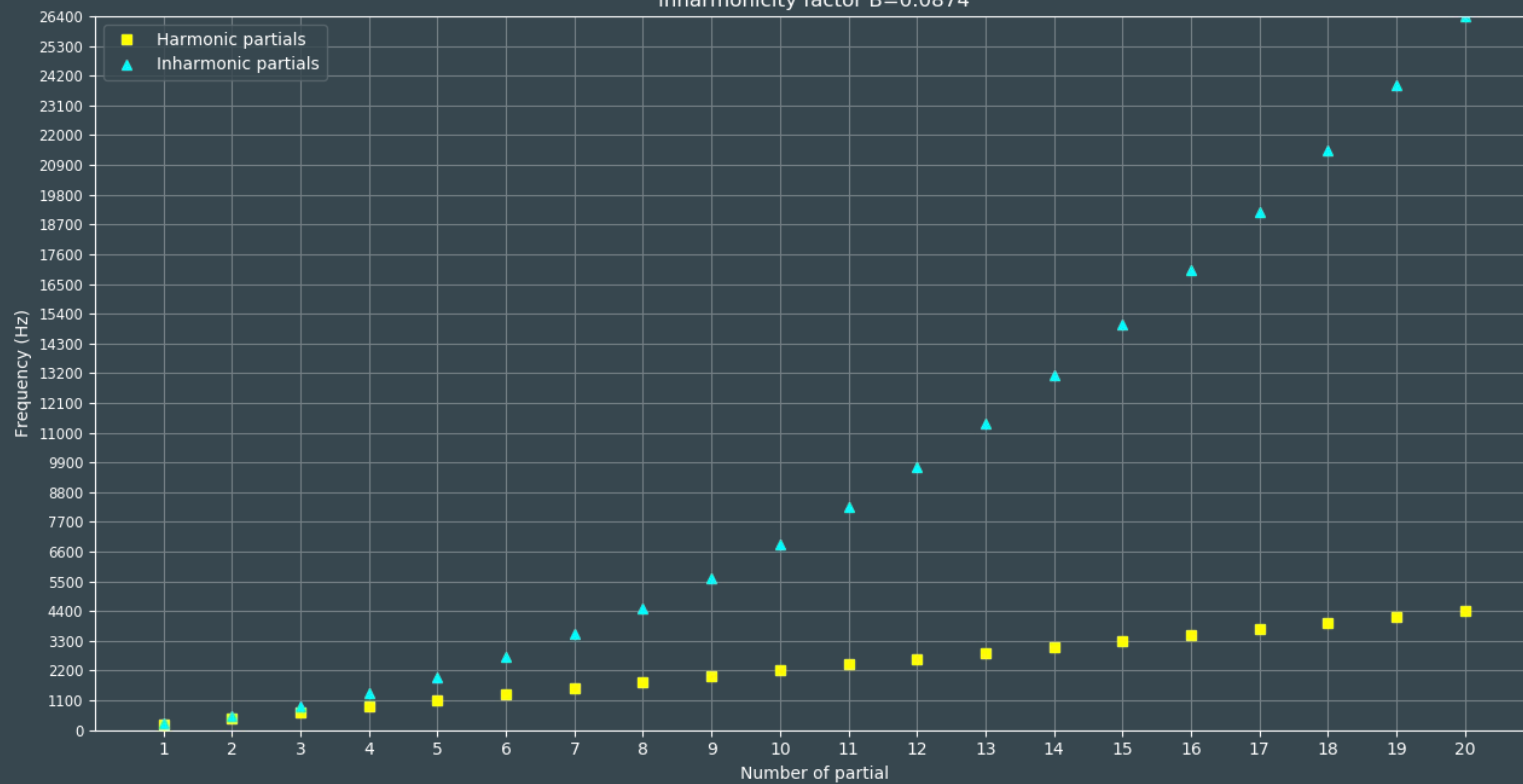
Fundamental frequency of 220Hz
Inharmonicity factor B=0.005



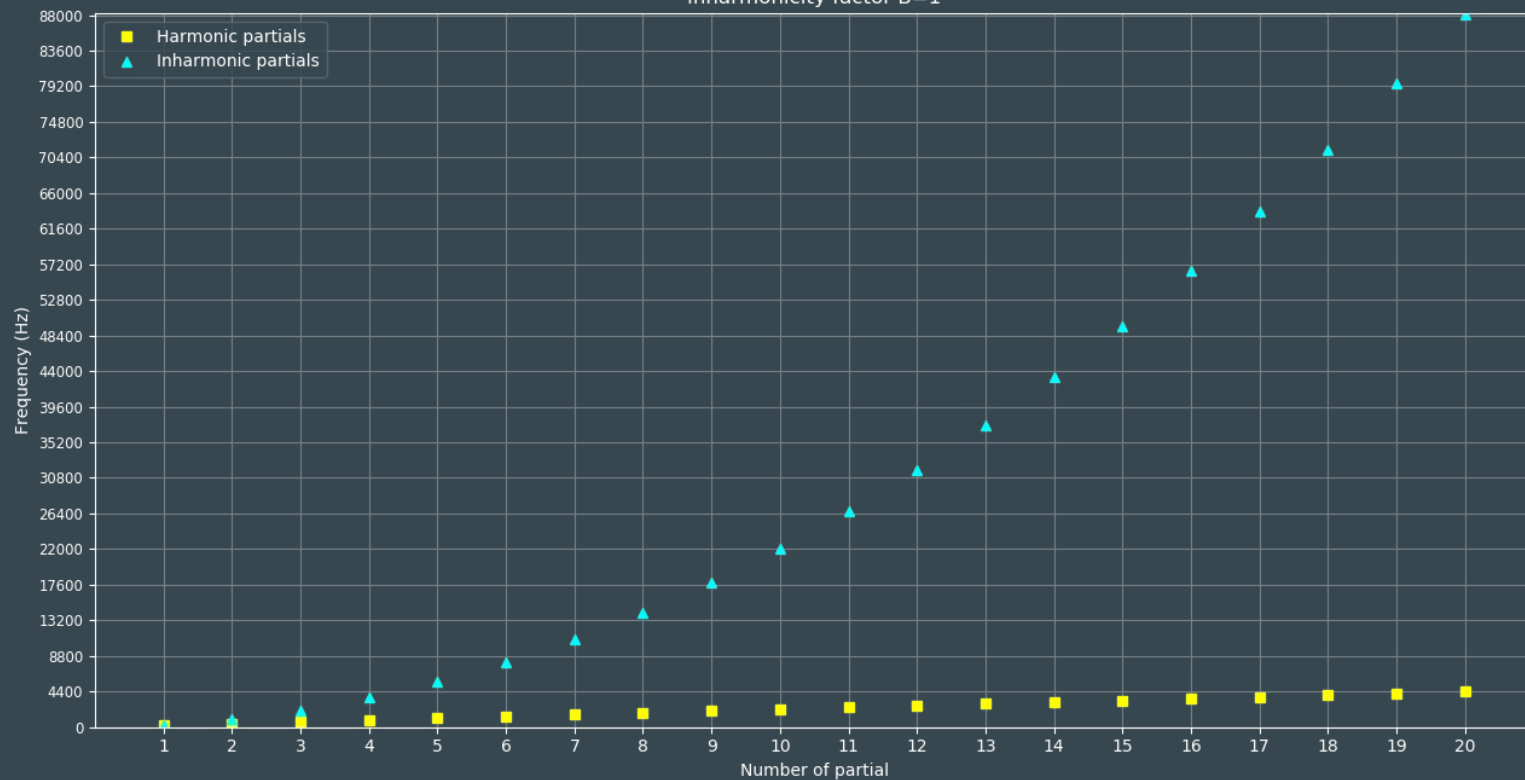
Fundamental frequency of 220Hz
Inharmonicity factor B=0.015



Fundamental frequency of 220Hz
Inharmonicity factor B=0.0874



Fundamental frequency of 220Hz
Inharmonicity factor B=1



References

Focusing on strings

- Järveläinen, H., Välimäki, V., & Karjalainen, M. (2001). Audibility of the timbral effects of inharmonicity in stringed instrument tones. *Acoustics Research Letters Online*, 2(3), 79-84.
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