

Dispersion Modulation using Allpass Filters

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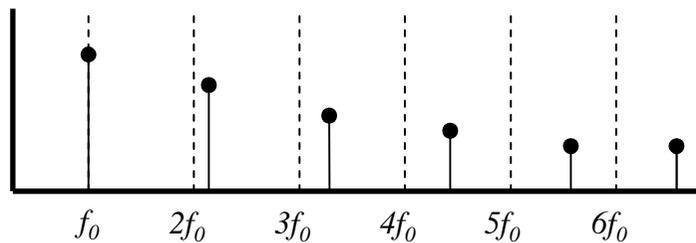
dispersion ◇
parameter ◇
modulation ◇

implementation ◇
results ◇

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Dispersion

- Different frequencies \Rightarrow Different velocities



causes inharmonicity

- **Strings**

- stiffness of string
- stretching factor B

$$B = \frac{\pi^3 E d^4}{64 L^2 T}$$

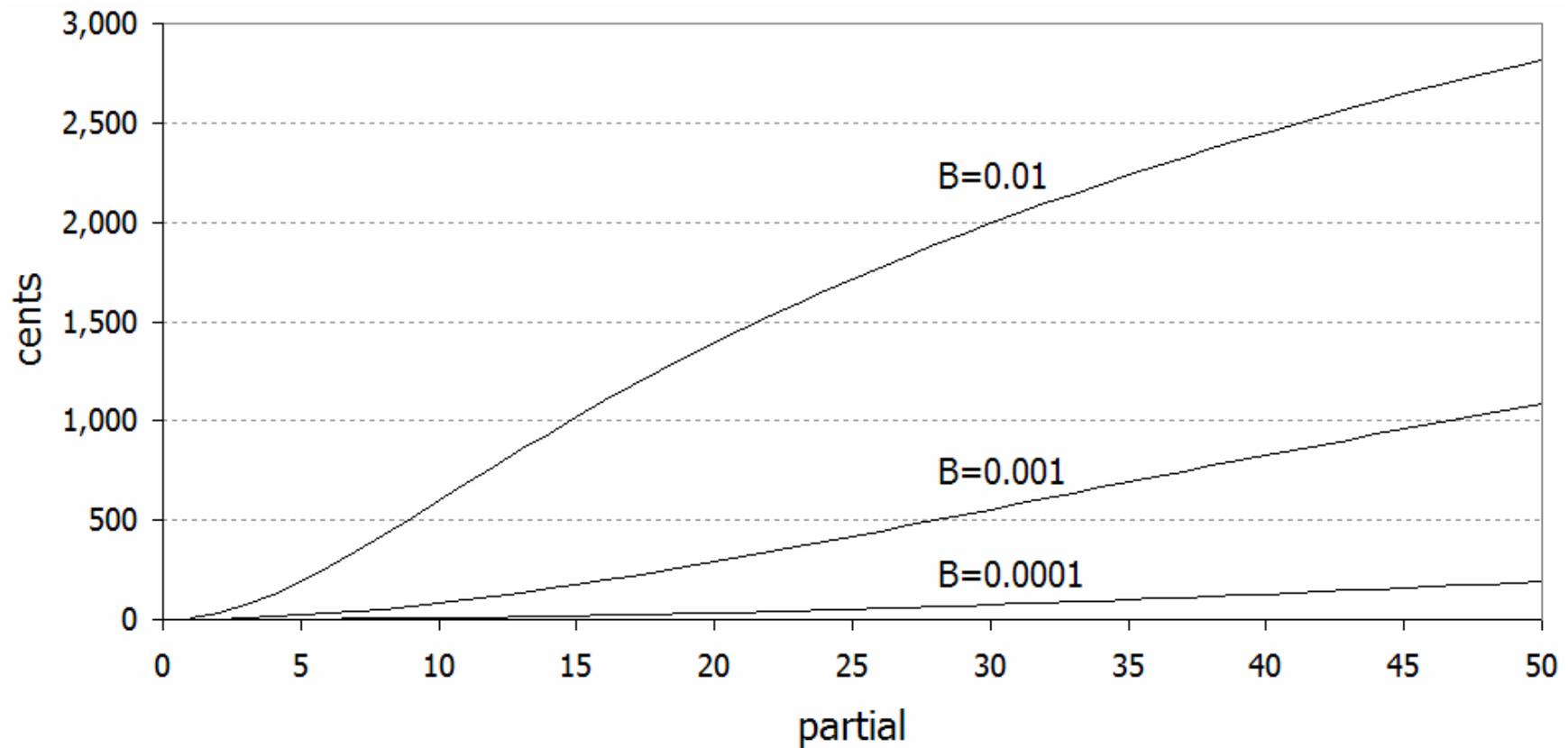
Young's modulus

- **Acoustic tubes**

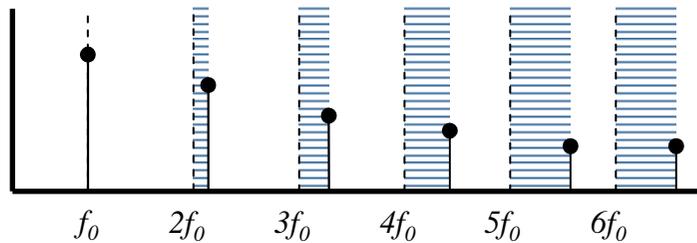
- stiffness of air
- only for impulsive excitation

Dispersion in Strings

- Stretching equation $f_n \approx nf_0 \sqrt{1 + Bn^2}$



Dispersion parameter + Modulation

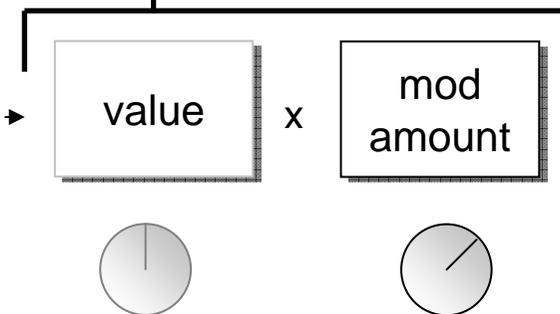


stretching factor

B

x scale

- Performer interaction
 - mod wheel, bender, aftertouch...
- Generators
 - LFO
 - Envelope (EG)
- Audio rate
 - Oscillator



constant into variable domain
+ expression and movement

Implementation

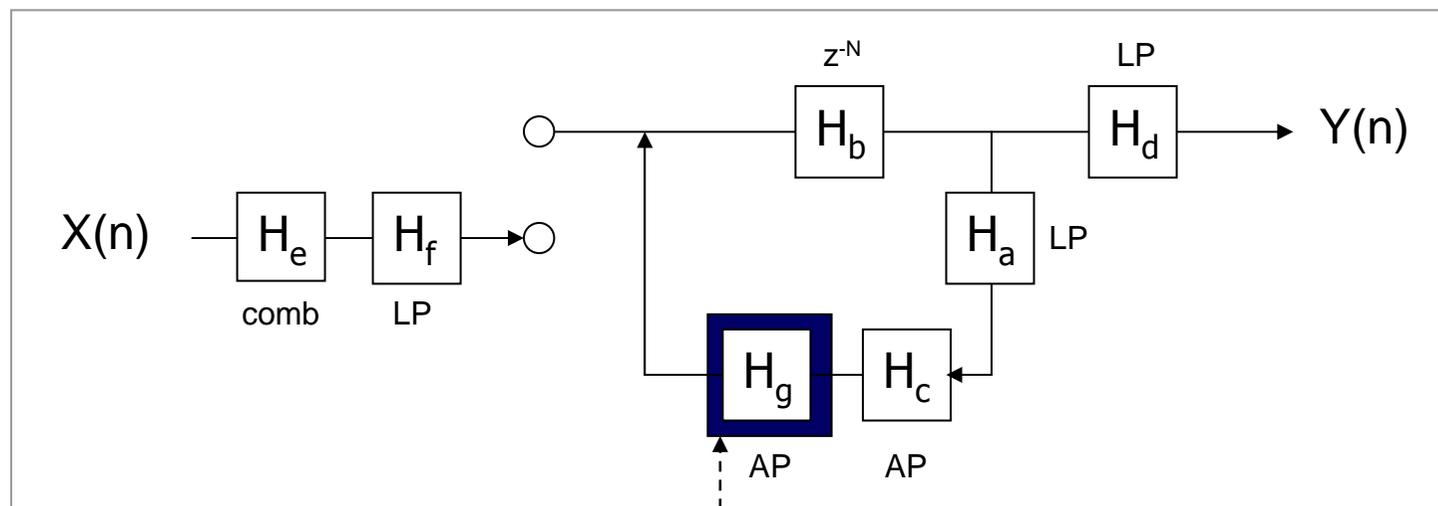
string
model

allpass

instrument

Extended Karplus-Strong

- Jaffe + Smith 1983



Dispersion
Modeling
Allpass

Implementation

string
model

allpass

instrument

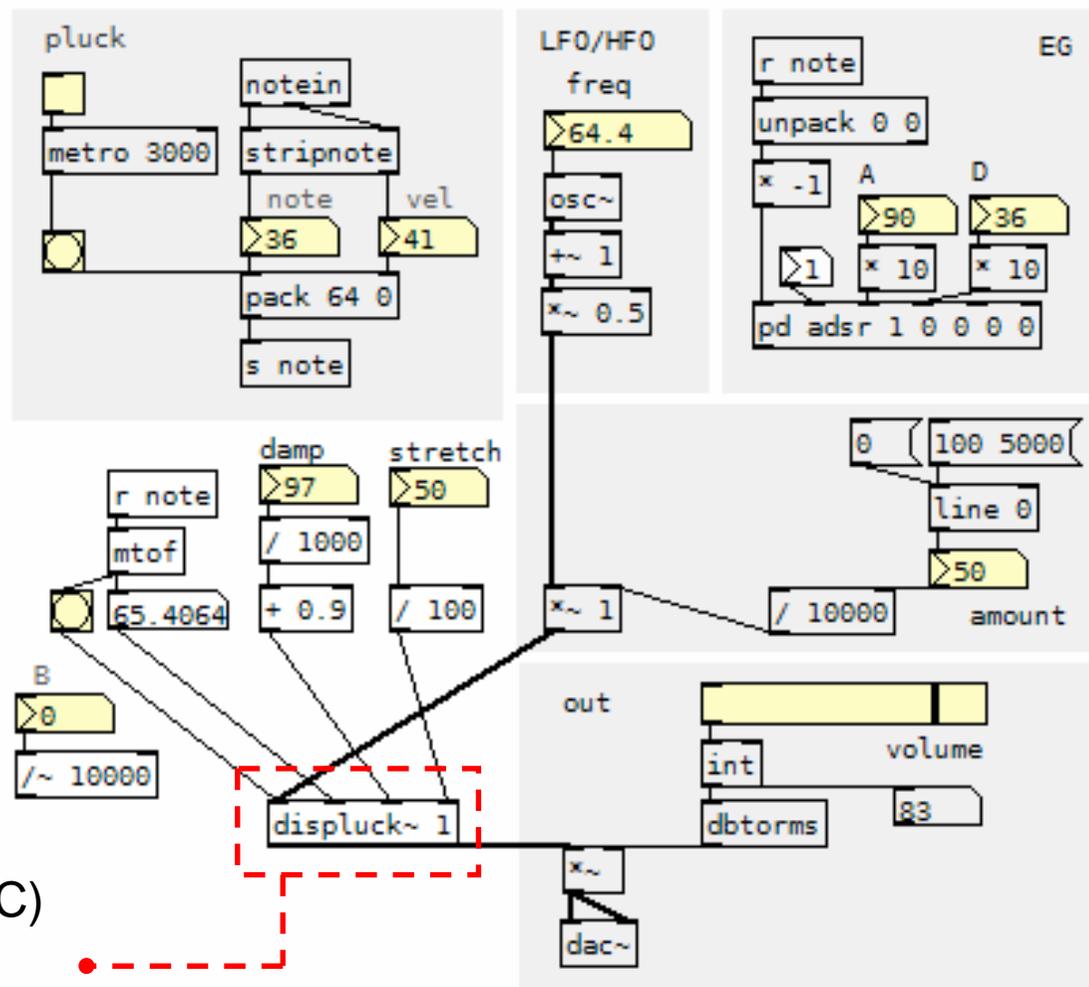
- Allpass Filters
 - flat magnitude response
 - arbitrary phase response \Rightarrow frequency dependent delay
- Tunable Dispersion Filter
 - Rauhala + Välimäki (2006)
 - cascade of (four) second-order allpasses
 - cascade of (eight) first-order allpasses
 - in:
 - f_0 : fundamental frequency
 - B : dispersion amount
 - M : number of allpass stages
 - out:
 - a_1 : allpass coefficient
 - amount of tuning compensation

Implementation

string
model

allpass

instrument



external (in C)

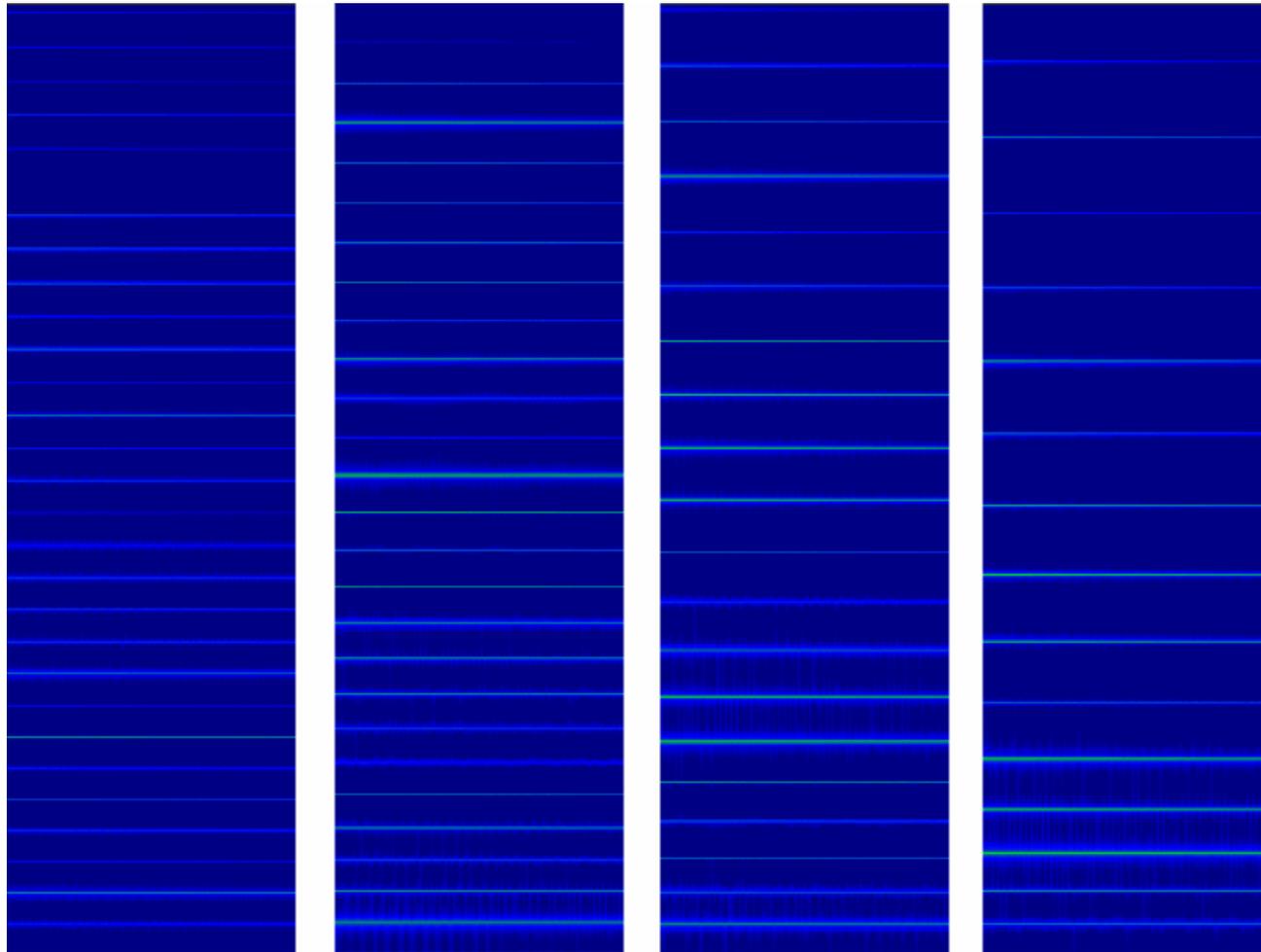
- EKS
- dispersion

Results – static properties

2 kHz



65 Hz



 0.0001

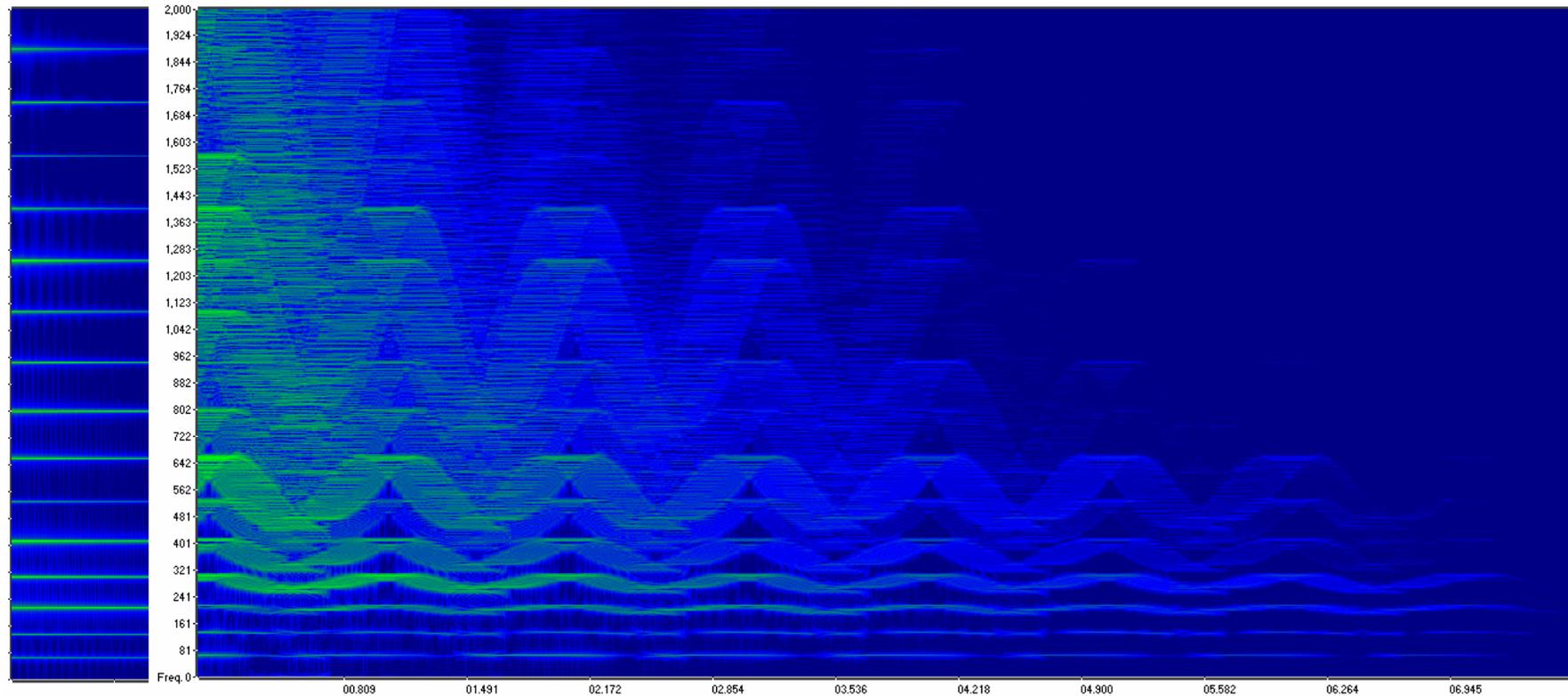
 0.001

 0.005

 0.01

B Range

Results – modulation (control rate)



(B=0.01)

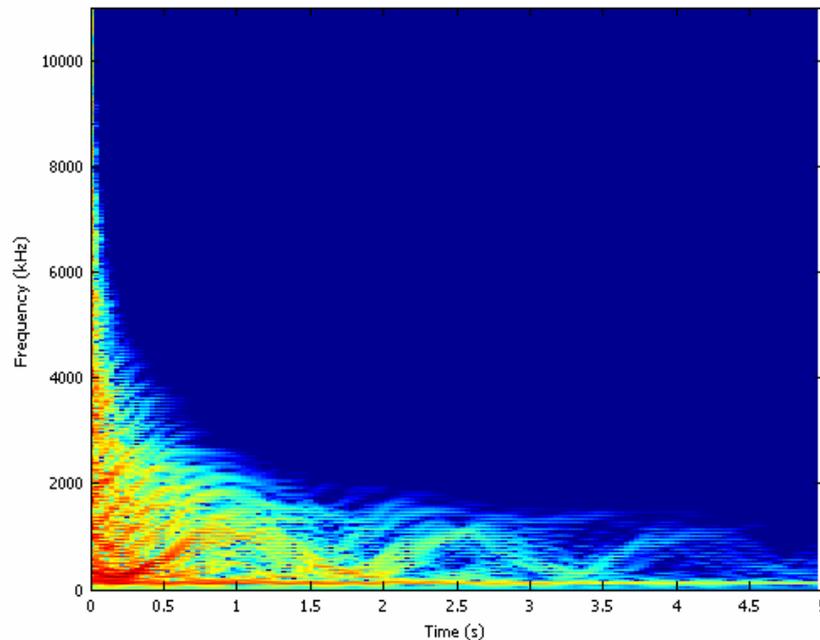


LFO : $\sin 1 \text{ Hz}$, $B = 0 \dots 0.01$

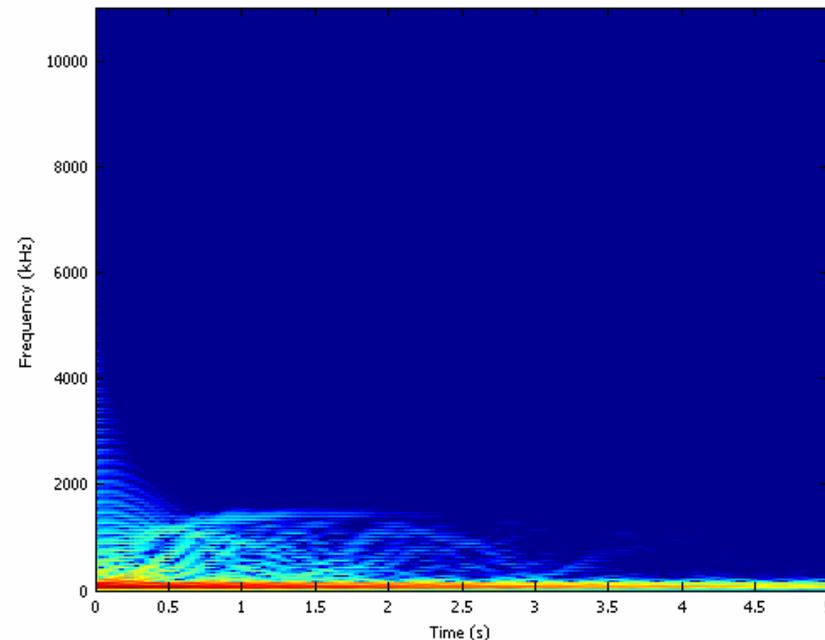
- tuning was difficult

Results – modulation (audio rate)

white noise excitation



sine excitation



max B deviation = 0.005, $c = 65.4$ Hz, $m = 64.4$ Hz

- $m/c \sim 0.5, 1.0, 1.5, 2.0 \dots$
- unstable with large ratios and high B values
- around 2% CPU

Conclusion

- Inharmonicity parameter B
 - range 0.0001 .. 0.01, logarithmic mapping
- Control rate modulation
 - smooth morph of inharmonicity
 - EG, LFO, performer gestures
- Audio rate modulation
 - phaser / chorus -like timbres
 - c/m ratios near 0.5, 1, 1.5, 2...
- Problems
 - tuning
 - instability when using arm