

Fourier Methods for Computational Analysis of Enharmonicism and Other Harmonic Properties.

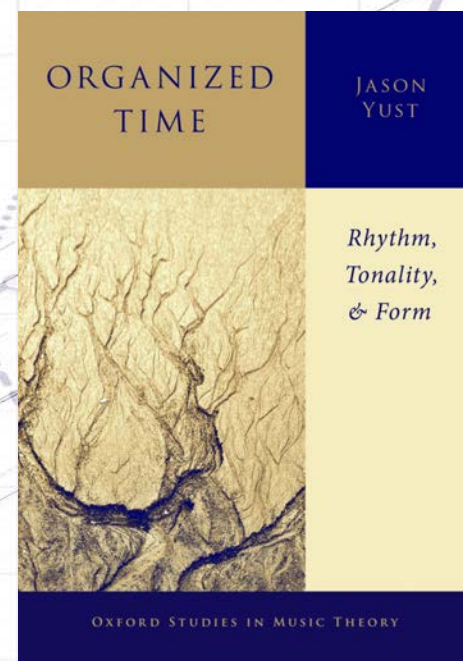
Méthodes basées sur la Transformée de Fourier pour l'analyse computationnelle de l'enharmonie et des autres propriétés harmoniques

Jason Yust,



<http://people.bu.edu/jyust>

Journées d'informatique musicale
Strasbourg, 26 octobre, 2020.



Méthode: Analyse par fenêtrage

Vecteurs des classes de hauteurs pour deux noires
(1,0,0,1,0,0,0,0,0,1,2,0)

(2,0,0,2,0,0,0,0,0,2,2,0)

(2,0,1,3,1,0,1,0,0,2,2,0)

etc.

The image shows a musical score for four instruments: Violino I, Violino II, Viola, and Violoncello. The tempo is marked 'Allegro'. The Violoncello part starts with a piano (*p*) dynamic and a slur over the first four measures. The Violino I part starts with a *dolce* marking and a slur over the first four measures. The Violino II part starts with a piano (*p*) dynamic and a slur over the first four measures. The Viola part starts with a piano (*p*) dynamic and a slur over the first four measures. The score is divided into measures, with some measures containing triplets (marked with a '3' and a slur). Blue arrows point from the vectors above to specific notes in the score: the first arrow points to the first note of the Violino I part, the second arrow points to the first note of the Violino II part, and the third arrow points to the first note of the Viola part.

Méthode: Analyse par fenêtrage

Vecteurs des classes de hauteurs pour quatre noires

(4,0,2,5,0,2,0,1,0,4,4,0)

(3,0,3,4,0,2,0,1,0,3,6,0)

etc.

Violino I

Violino II

Viola

Violoncello

Allegro

dolce

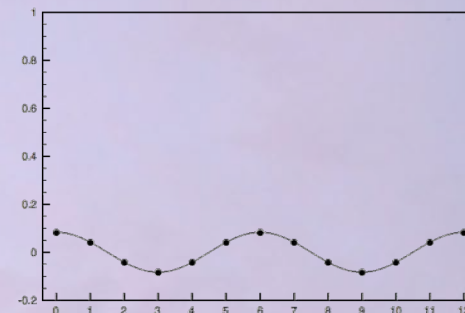
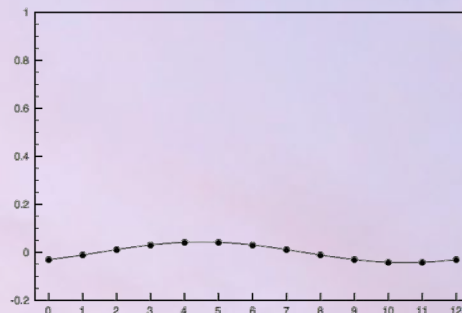
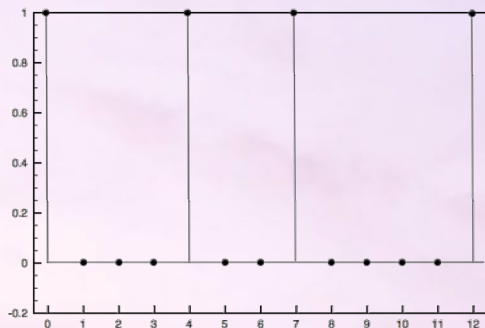
p

mf

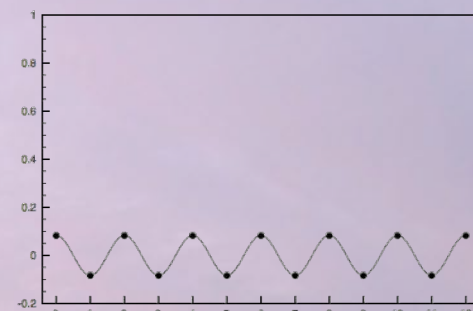
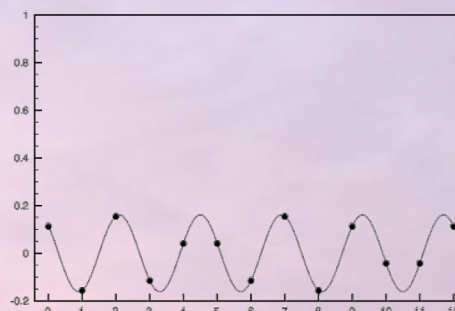
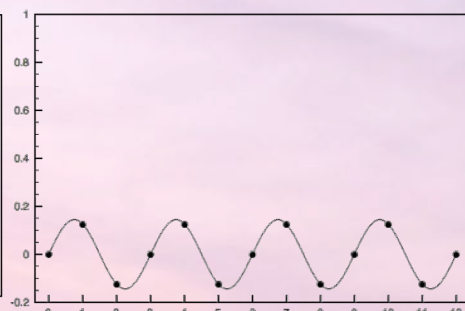
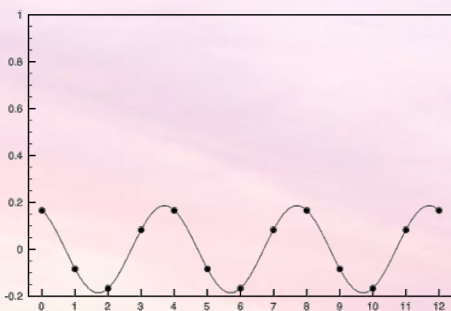
3

Coefficients de la TFD

Triad de do majeur = f_0 + f_1 + f_2



+ f_3 + f_4 + f_5 + f_6 + ...



La TFD transforme un vecteur des classes des hauteurs en douze fonctions periodiques

Analyse TFD données de Prince et Schmuckler

Majeur:

Composer	$ f_1 ^2$	$ f_2 ^2$	$ f_3 ^2$	$ f_4 ^2$	$ f_5 ^2$	$ f_6 ^2$	Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6
Bach	2	79	150	10	2095	2	9.89	0.96	0.38	3.74	1.96	6
Mozart	9	243	310	1	2158	4	9.34	11.91	0.96	8.04	1.66	0
Beethoven	4	182	287	7	1427	0	8.31	11.53	1.34	6.43	1.53	6
Schubert	7	127	337	18	1931	0	8.25	0.18	1.06	7.70	1.65	0
Chopin	10	186	357	1	1638	1	7.43	11.72	1.03	8.22	1.26	0
Brahms	2	49	224	5	1009	2	7.74	0.27	0.68	9.37	1.59	0
Liszt	5	85	402	30	394	43	6.21	0.12	0.68	9.37	1.59	0
Scriabin	11	117	352	47	2154	2	8.93	1.09	0.89	7.12	1.93	6

Mineur:

Composer	$ f_1 ^2$	$ f_2 ^2$	$ f_3 ^2$	$ f_4 ^2$	$ f_5 ^2$	$ f_6 ^2$	Ph_1	Ph_2	Ph_3	Ph_4	Ph_5	Ph_6
Bach	8	69	208	49	1489	3	8.72	10.80	2.29	2.60	11.60	6
Mozart	17	195	656	10	1515	6	8.97	10.53	2.24	0.15	11.91	6
Beethoven	2	239	457	5	1150	16	6.33	10.18	2.51	1.73	11.70	6
Schubert	9	238	540	14	1815	1	9.20	10.47	2.62	11.76	11.93	0
Chopin	0	149	336	6	1002	6	6.57	10.36	2.39	2.21	11.88	6
Brahms	9	194	390	2	847	19	8.23	9.89	1.87	2.14	11.68	6
Liszt	0	254	651	1	1179	14	4.83	10.75	1.75	1.30	0.40	6
Scriabin	5	237	399	48	1524	19	10.10	10.88	1.25	0.61	11.91	0

From Yust, J. 2017. “Probing Questions about Keys: Tonal Distributions through the DFT.” *Mathematics and Computation in Music* 2017.
 Prince, J.B. & Schmuckler, M.A. 2014. “The Tonal-Metric Hierarchy: A Corpus Analysis.” *Music Perception* 31.

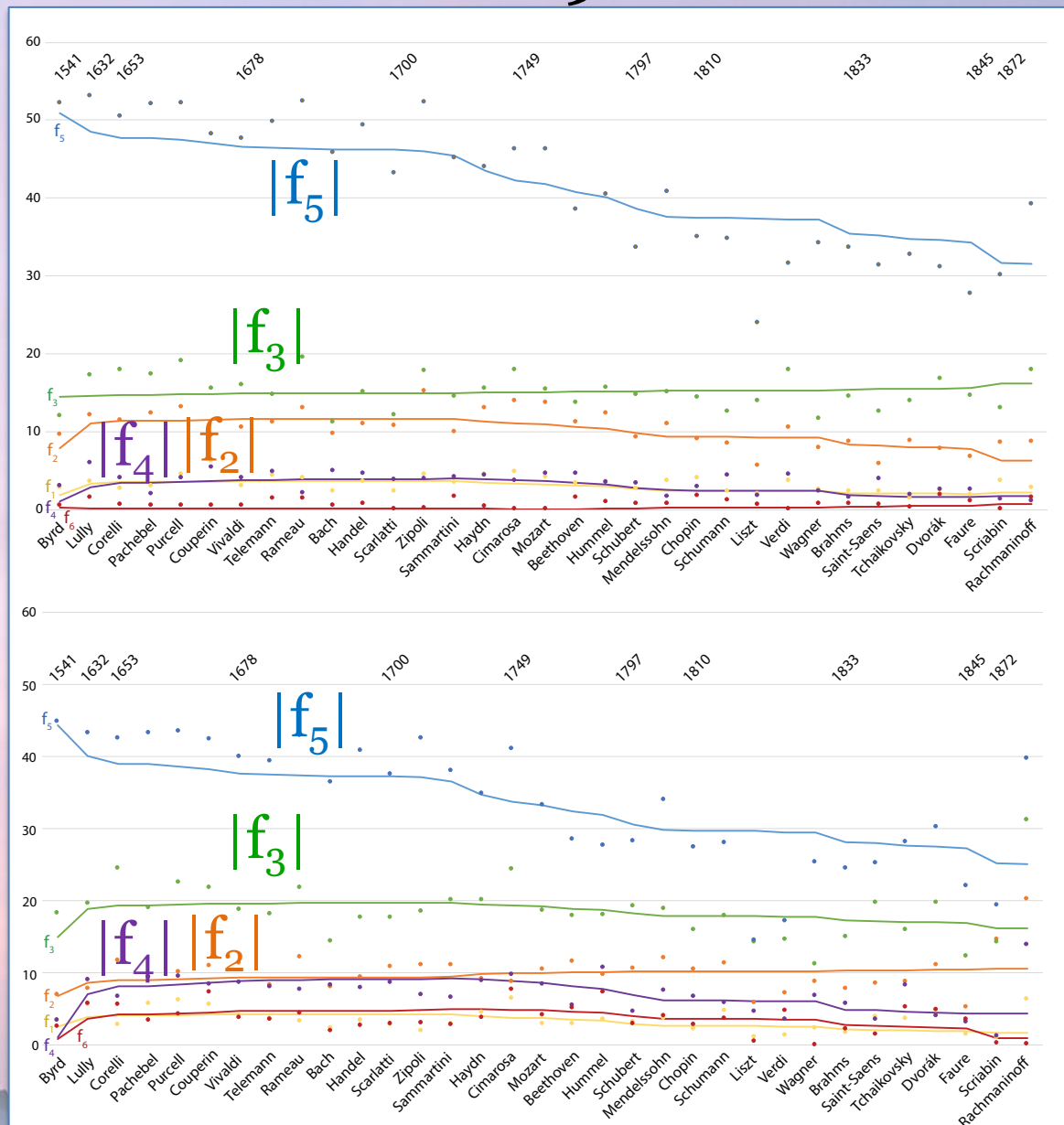
Résultats de Yust 2019

Analyse des pièces
entières de Yale
Classical Archives

Majeur:

Yust, J. 2019 “Stylistic
Information in Pitch-
Class Distributions.”
*Journal of New Music
Research* 48/3

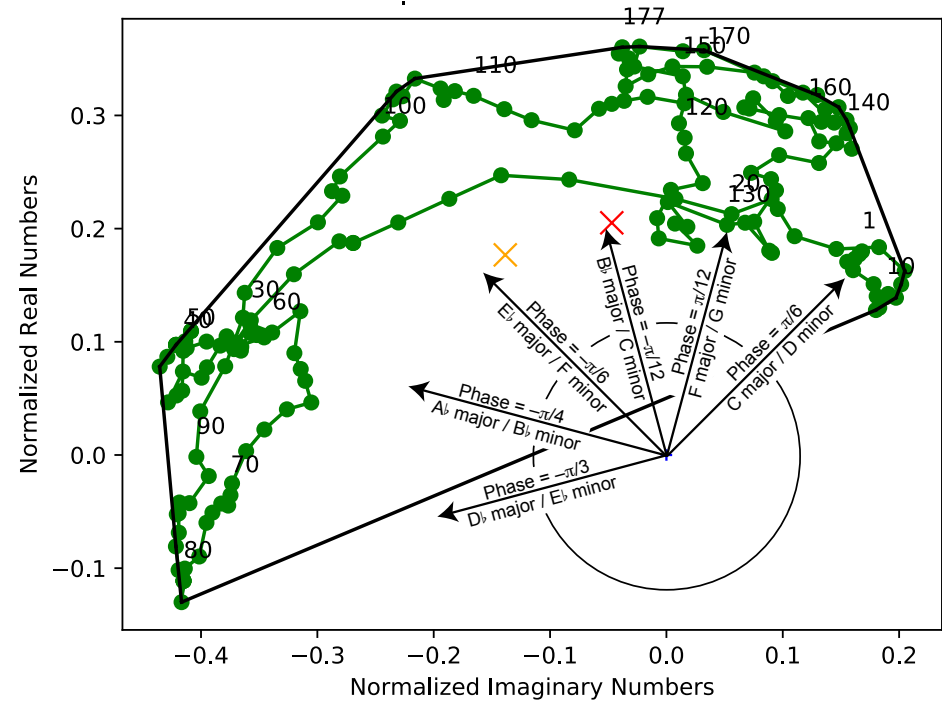
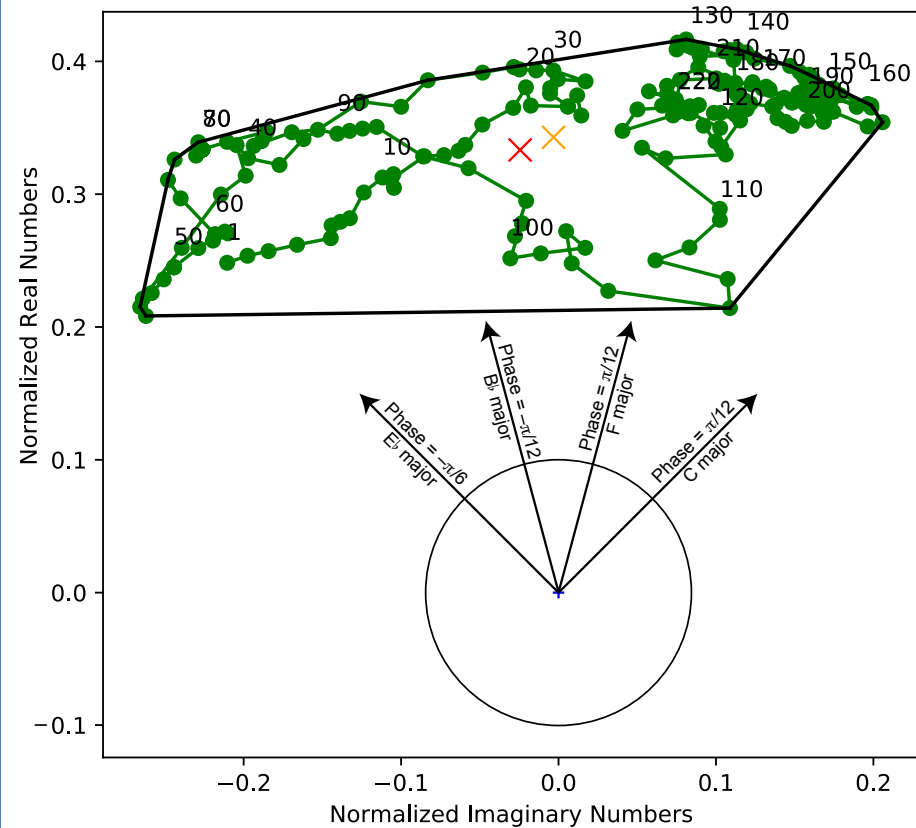
Mineur:



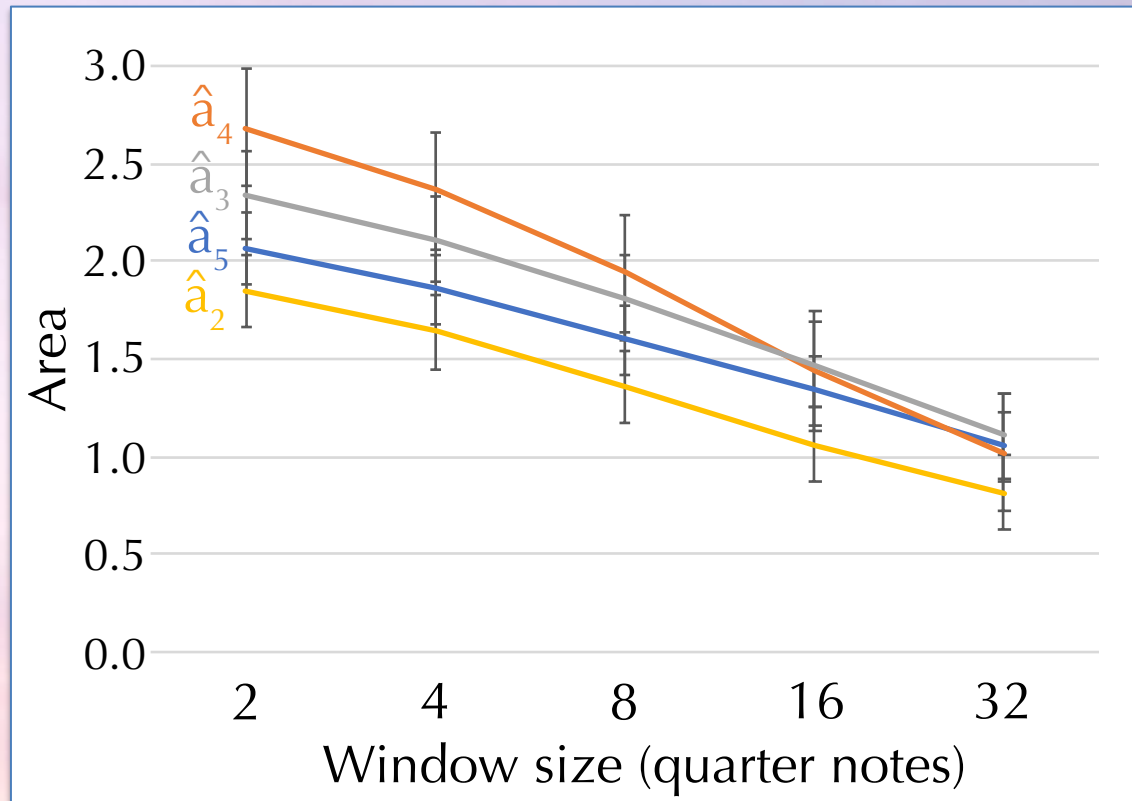
Example: Haydn Op. 50/1

Exposition, f_5 :

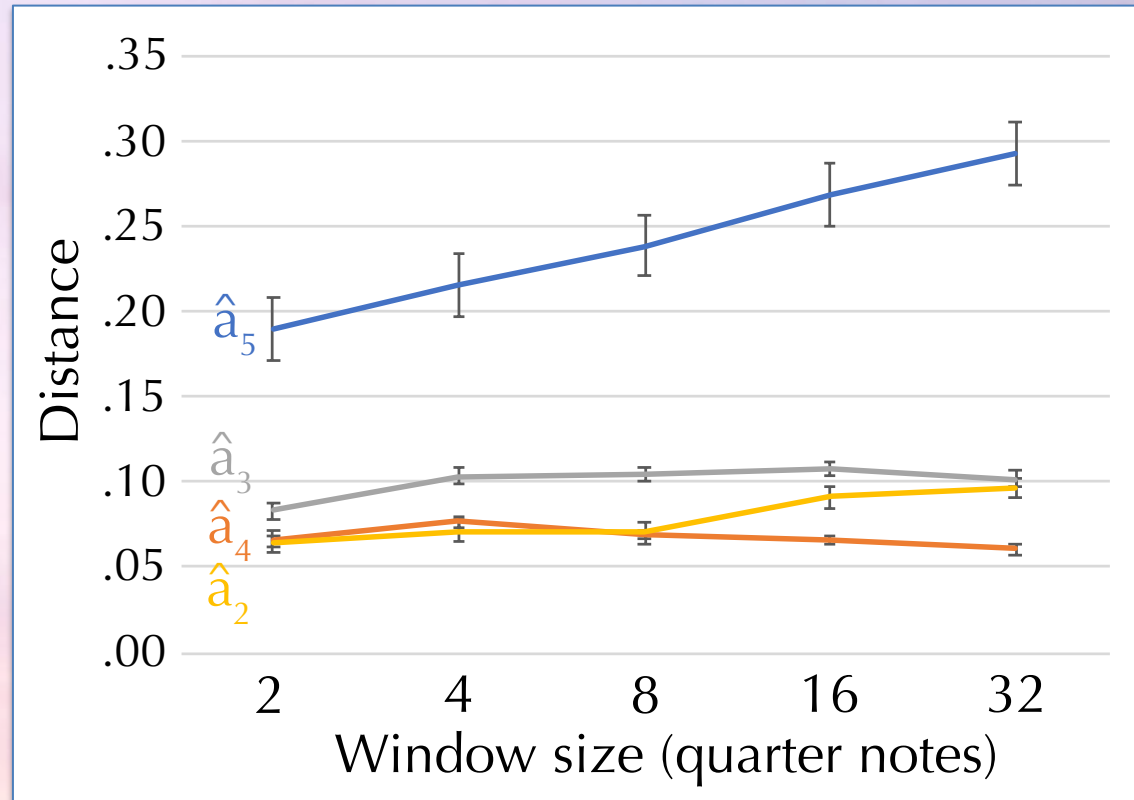
Développement, f_5 :



Aire de l'enveloppe convexe par taille de fenêtre



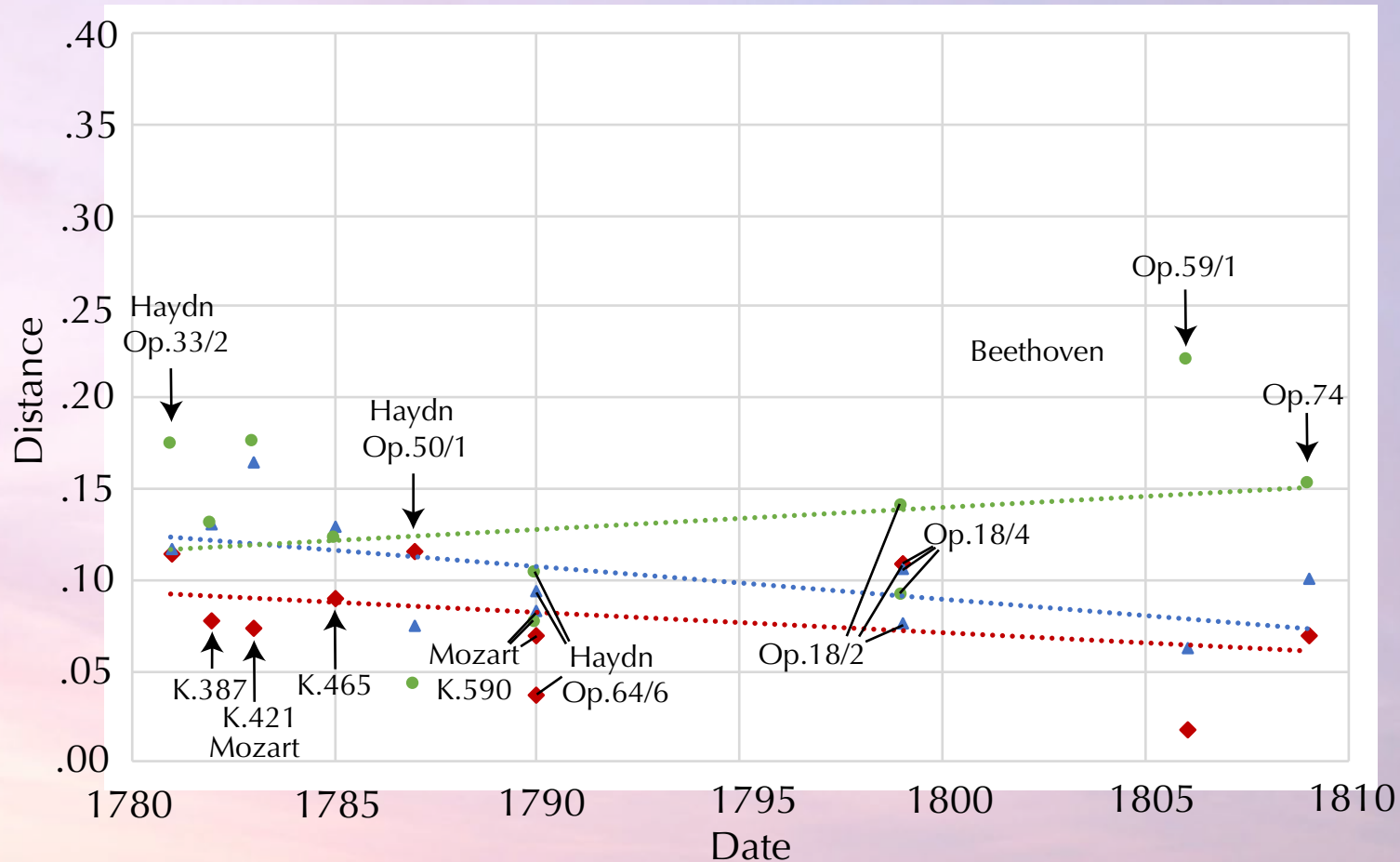
Distance de l'origine par taille de fenêtre



Modèle de régression pour les distances

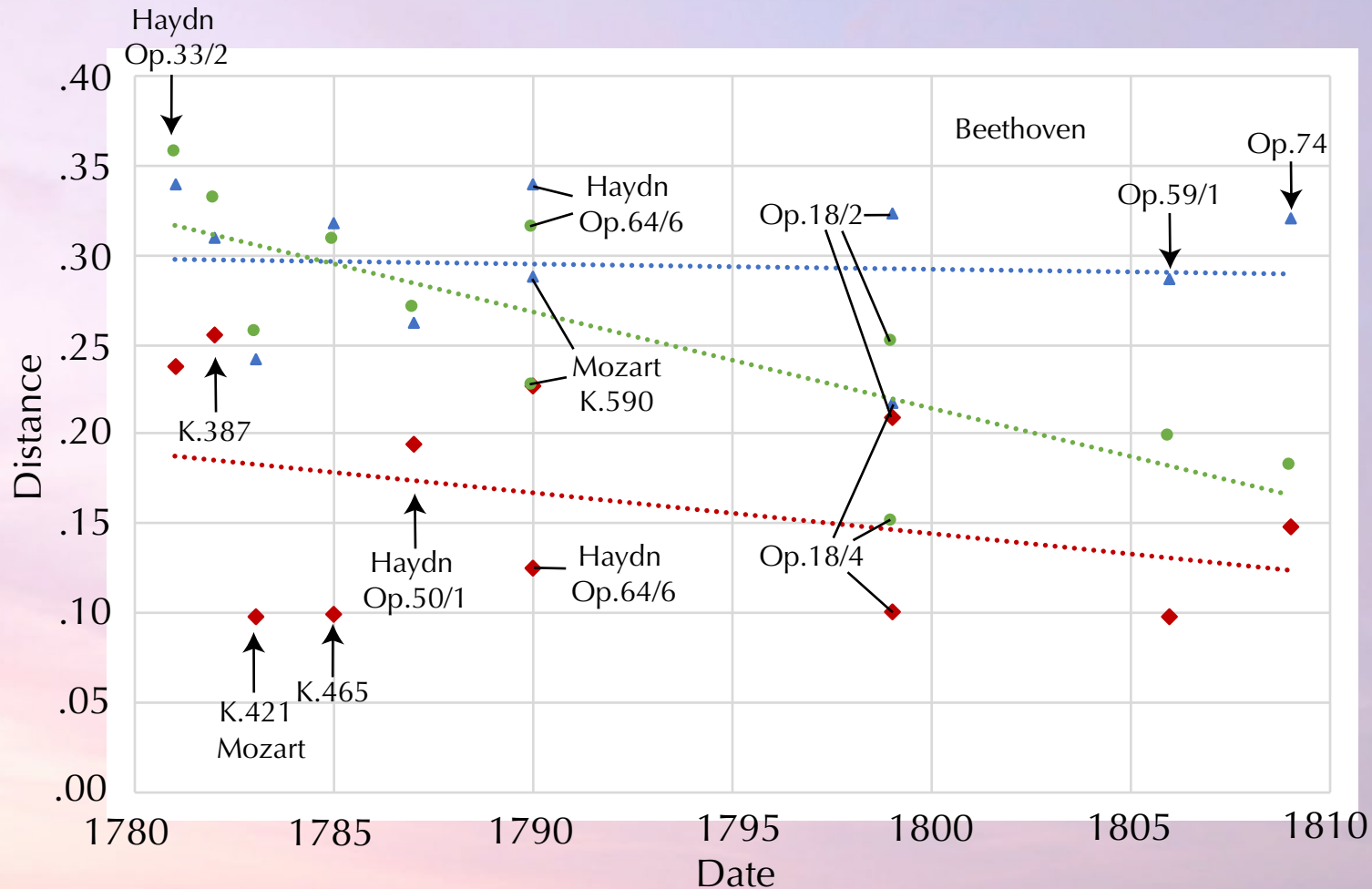
Factor	Coeff.	sig.
Date	-0.0002	—
Expo	0.0242	—
Recap	0.0282	—
$\hat{a}_3$	0.5824	—
$\hat{a}_4$	-5.050	$p < .01$
$\hat{a}_5$	4.766	$p < .01$
Minor	0.0114	—
Date $\times \hat{a}_3$	-0.0003	—
Date $\times \hat{a}_4$	0.0028	$p < .01$
Date $\times \hat{a}_5$	-0.0026	$p < .01$
Expo $\times \hat{a}_3$	-0.0008	—
Recap $\times \hat{a}_3$	0.0214	—
Expo $\times \hat{a}_4$	-0.0346	—
Recap $\times \hat{a}_4$	-0.0243	—
Expo $\times \hat{a}_5$	0.1080	$p < .0001$
Recap $\times \hat{a}_5$	0.0677	$p < .01$
Minor $\times \hat{a}_3$	0.0064	—
Minor $\times \hat{a}_4$	-0.0212	—
Minor $\times \hat{a}_5$	-0.0893	$p < .001$

Distance de l'origine par date pour f_3



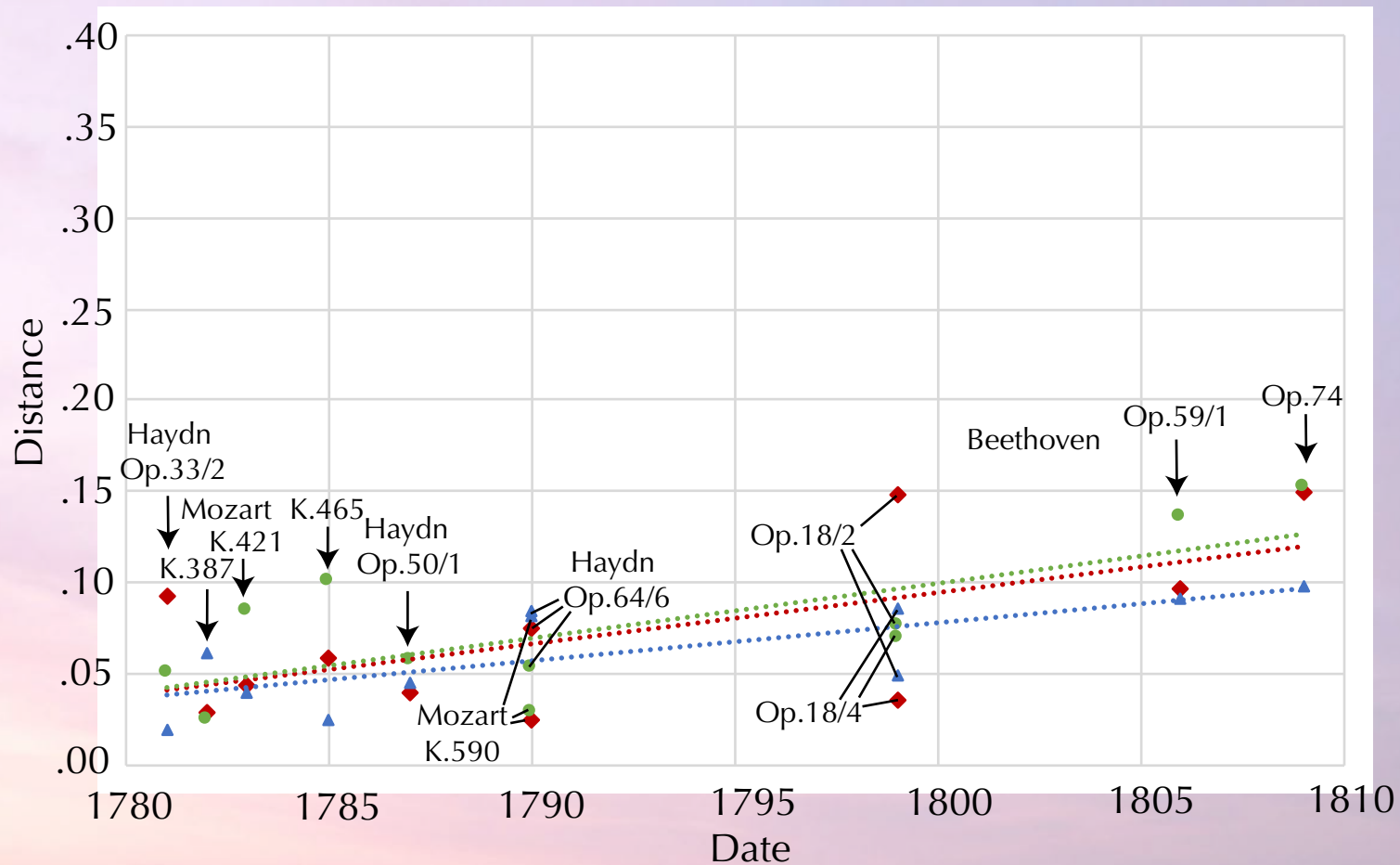
Verte: l'exposition, Rouge: le développement, Bleu: la réexposition

Distance de l'origine par date pour f_5



Verte: l'exposition, Rouge: le développement, Bleu: la réexposition

Distance de l'origine par date pour f_4

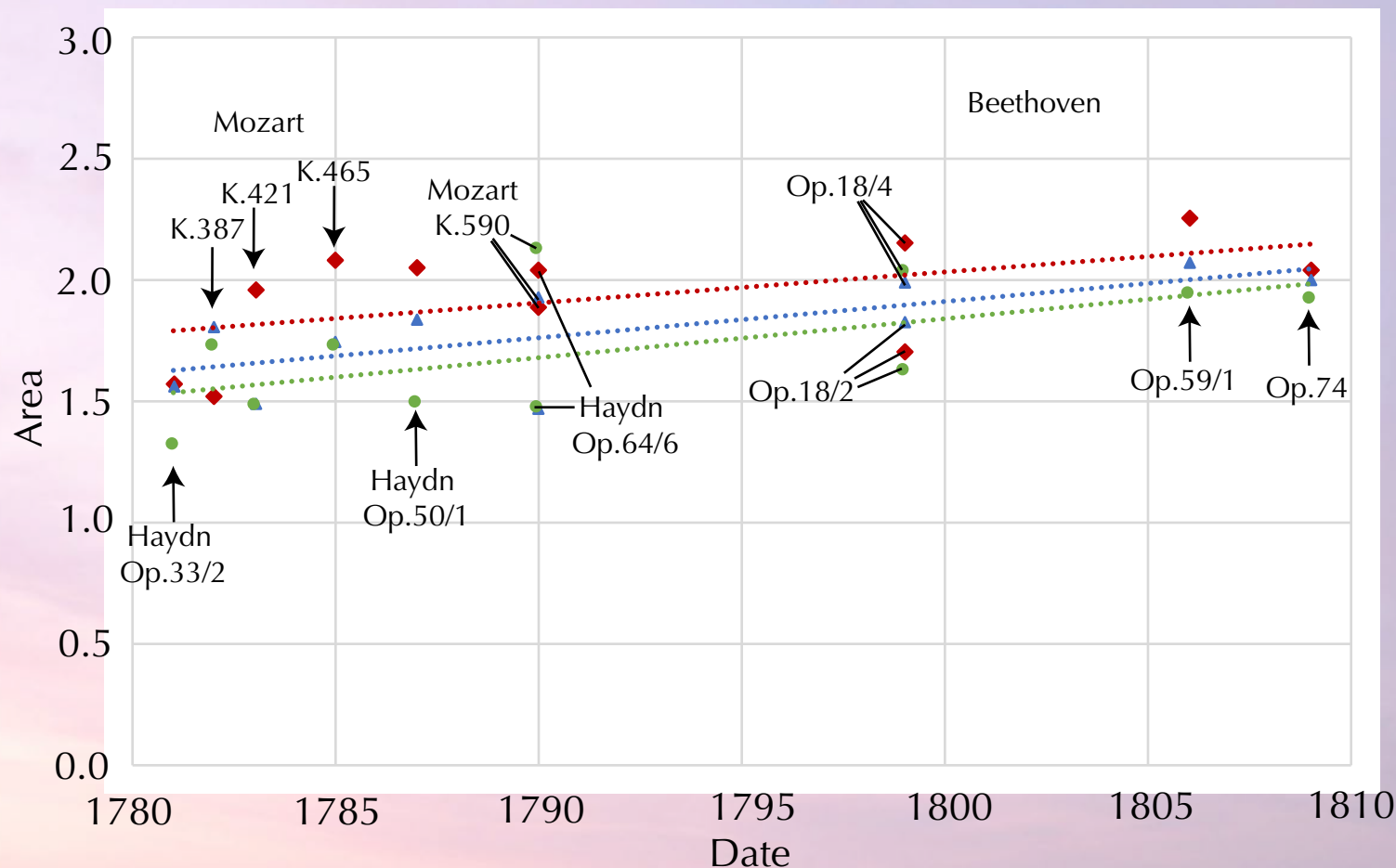


Verte: l'exposition, Rouge: le développement, Bleu: la réexposition

Modèle de régression pour les aires

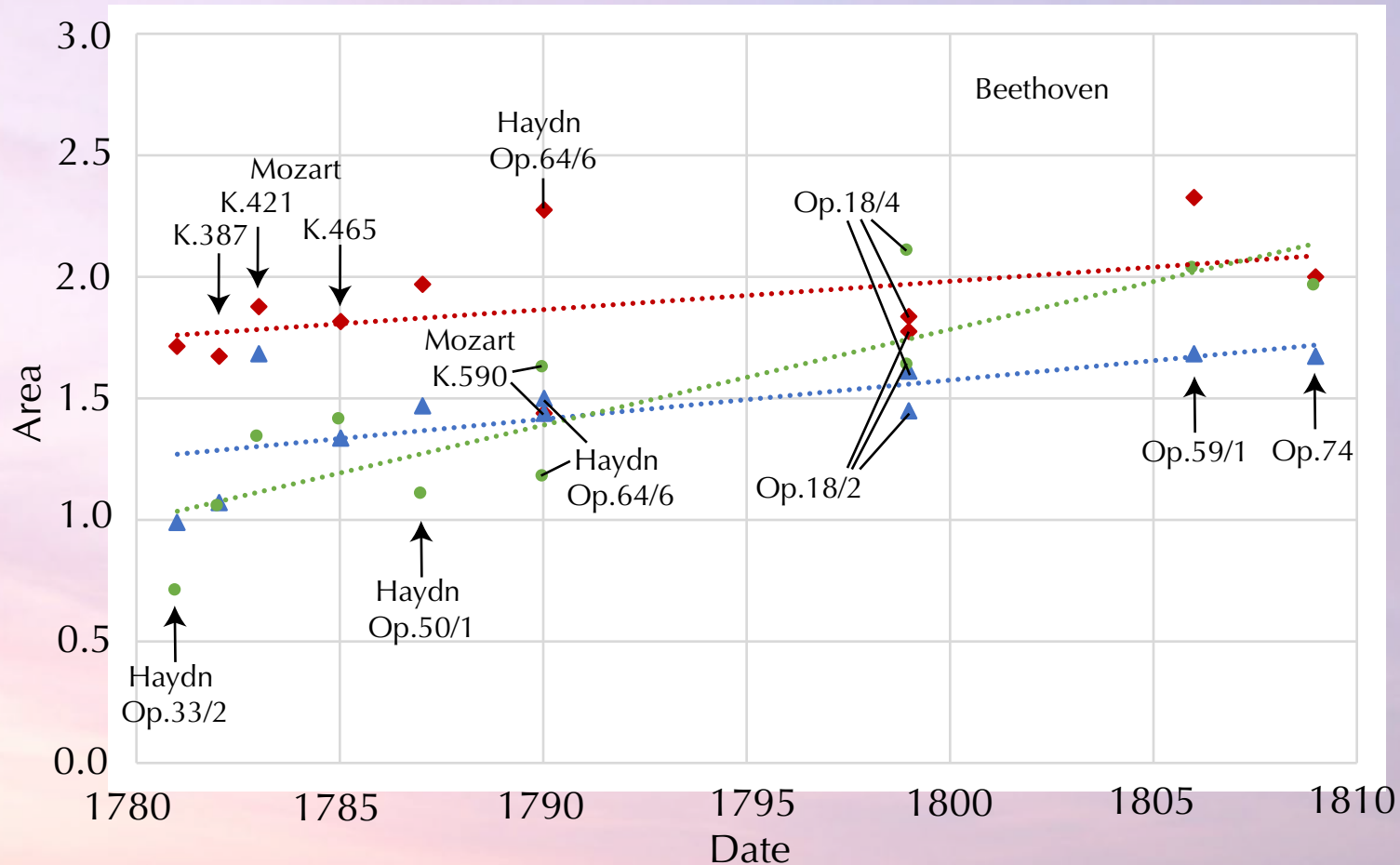
Factor	Coeff.	sig.
Date	0.0237	$p < .0001$
Expo	-0.2901	$p < .0001$
Recap	-0.3512	$p < .0001$
$\hat{a}_3$	0.3741	$p < .01$
$\hat{a}_4$	0.1424	—
$\hat{a}_5$	0.0850	—
Haydn	0.2738	$p < .01$
Mozart	0.3041	$p < .01$
Minor	0.1463	$p < .01$
Length	0.0005	—
$\text{Length} \times \hat{a}_3$	0.0003	—
$\text{Length} \times \hat{a}_4$	0.0017	$p < .001$
$\text{Length} \times \hat{a}_5$	0.0002	—

L'aire de l'enveloppe convexe par date pour f_3



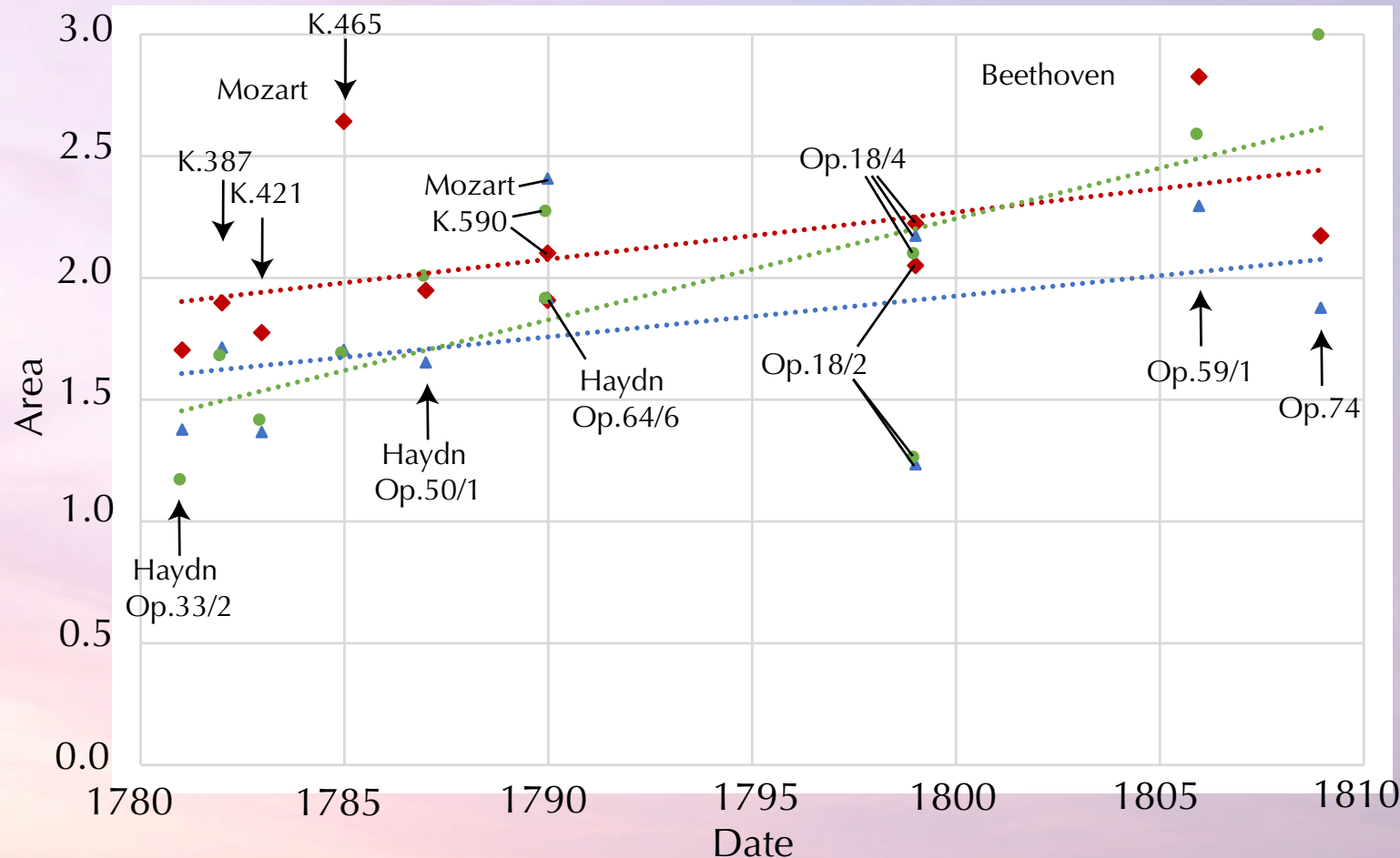
Verte: l'exposition, Rouge: le développement, Bleu: le réexposition

L'aire de l'enveloppe convexe par date pour f_5



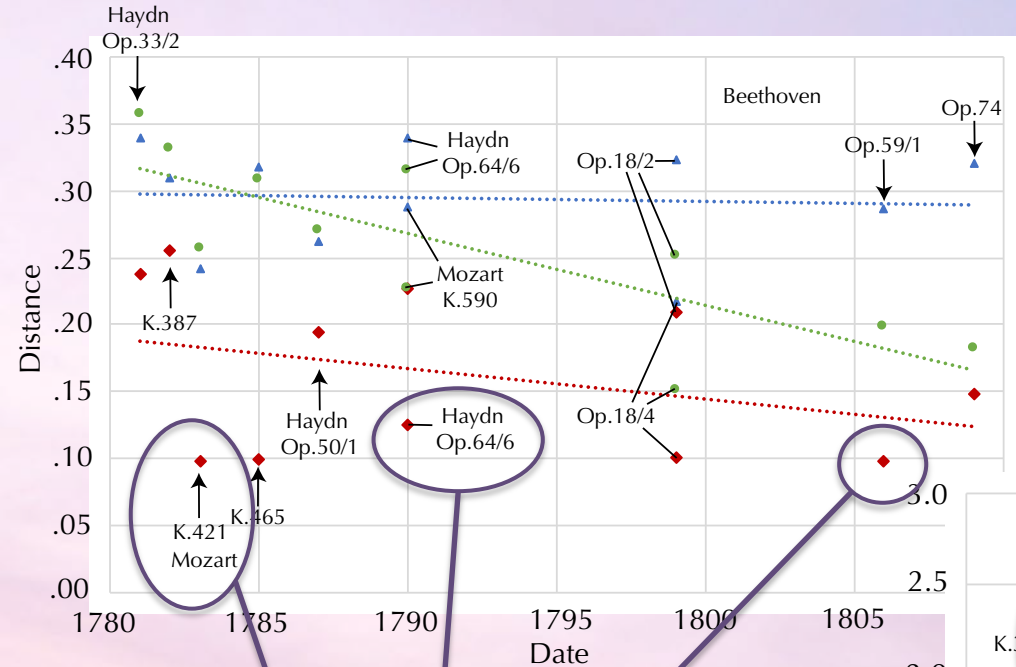
Verte: l'exposition, Rouge: le développement, Bleu: la réexposition

L'aire de l'enveloppe convexe par date pour f_4



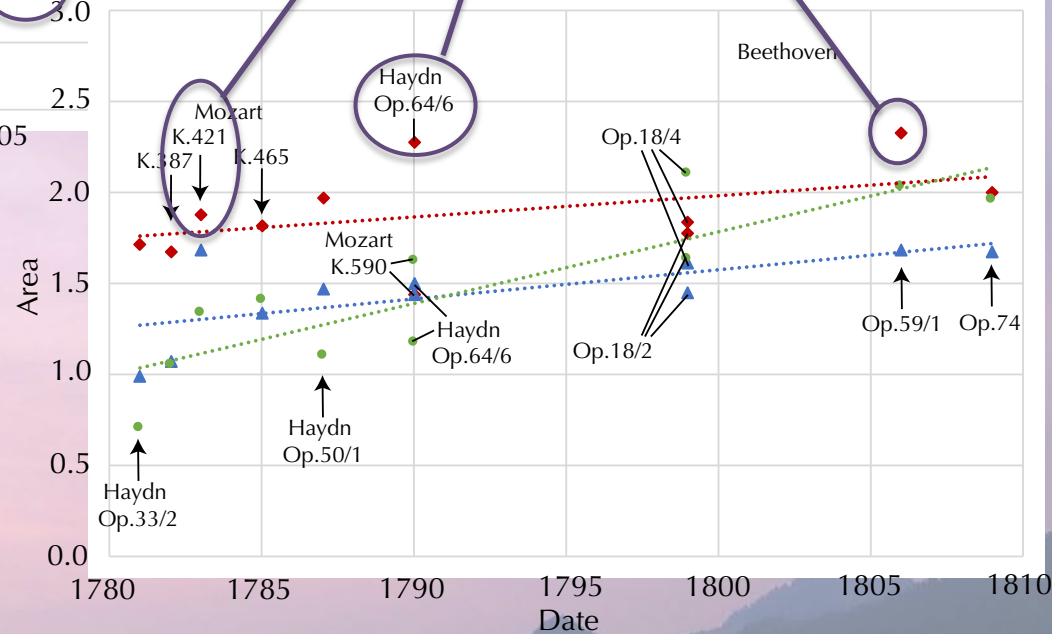
Verte: l'exposition, Rouge: le développement, Bleu: la réexposition

Exemples d'enharmonie



Distance minimale

Aire maximale

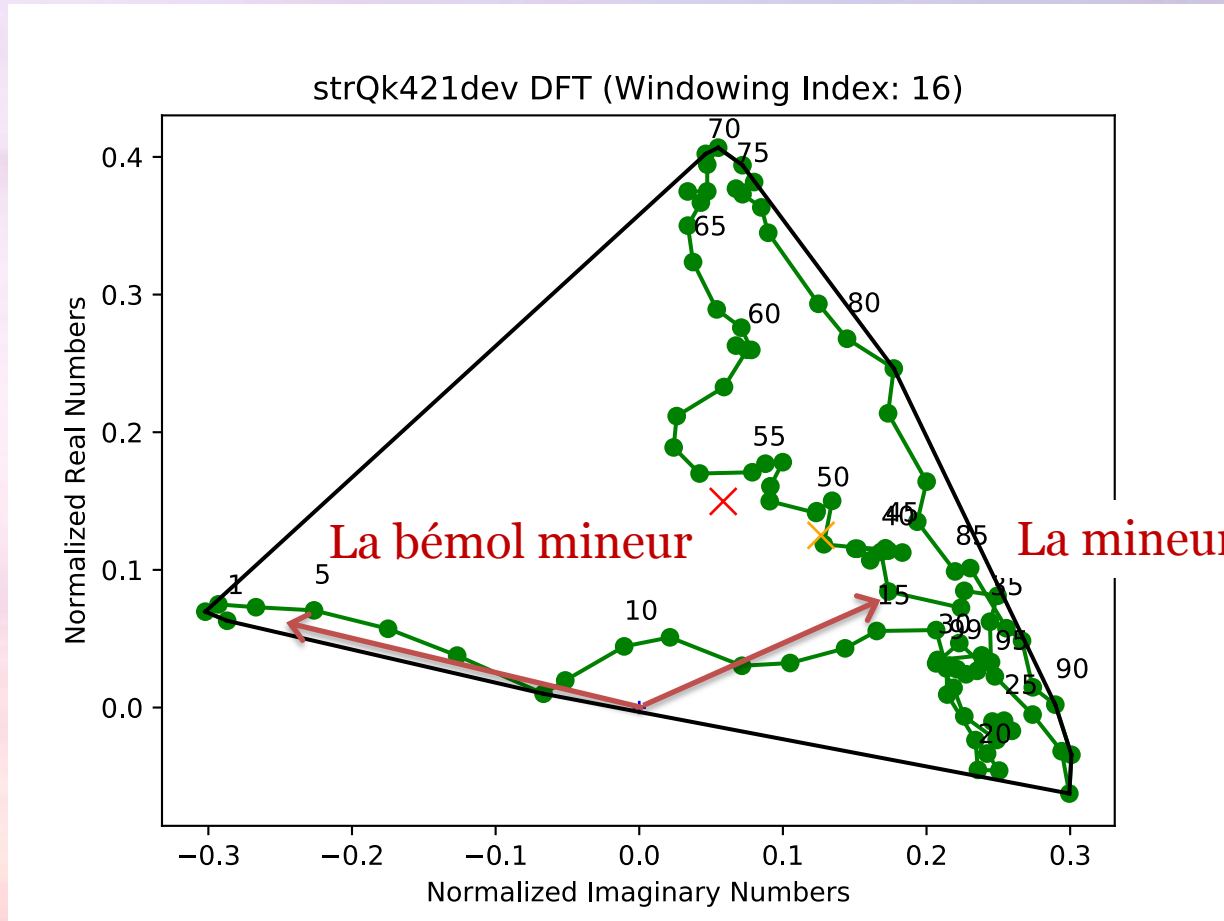


Verte: l'exposition, Rouge: le développement, Bleu: le réexposition

Mozart K.421, Développement

[illegible]

Mozart K.421, Développement



Haydn Op. 64 no. 6, Développement



Mi bémol

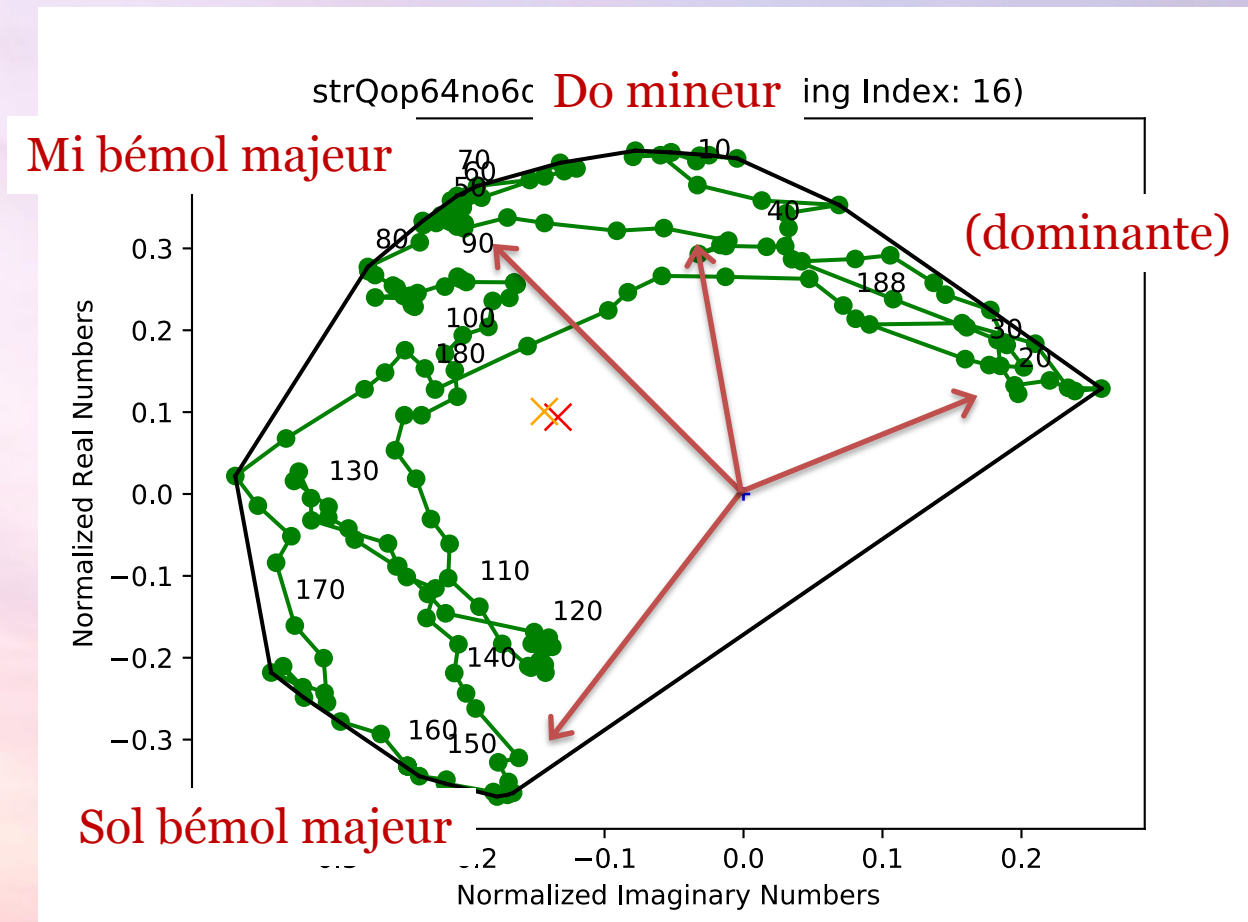


Sol bémol majeur



Do mineur (dominante)

Haydn Op. 64 no. 6, Développement

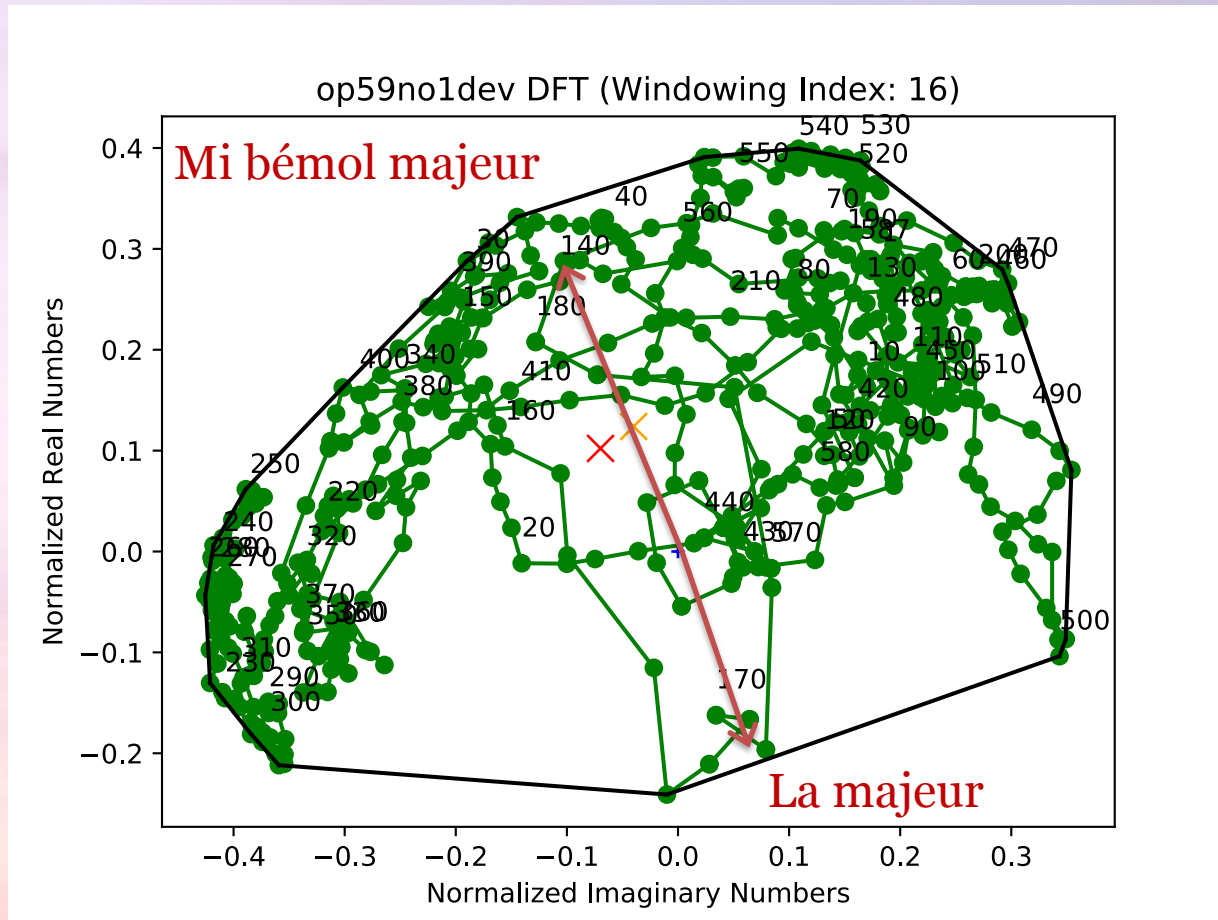


Beethoven Op. 59 no. 1, Développement

The image displays a musical score for a piece titled "Mi bémol majeur (napolitaine) La majeur". The score is written for four staves (two treble and two bass clefs) and includes dynamic markings such as *sf*, *f*, *p*, *cresc.*, and *sempre stacc. e p*. The key signature is one flat (B-flat major). The score is divided into three systems, with measure numbers 138, 146, and 157 indicated at the beginning of each system. The notation includes various musical symbols, including notes, rests, and slurs, indicating a complex and expressive composition.

Mi bémol majeur (napolitaine) La majeur (dominante)

Beethoven Op. 59 no. 1, Développement



Fourier Methods for Computational Analysis of Enharmonicism and Other Harmonic Properties.

Méthodes basées sur la Transformée de Fourier pour l'analyse computationnelle de l'enharmonie et des autres propriétés harmoniques

Jason Yust,



<http://people.bu.edu/jyust>

Journées d'informatique musicale
Strasbourg, 26 octobre, 2020.

