

Orbital Resonance

for three retuned, computer-driven pianos

by Kyle Gann

2015

Orbital Resonance (2015)

When the New Horizons spacecraft took its historic photos of Pluto in July 2015, there was a lot written about Pluto. I learned, for instance, for the first time, that although the orbits of Pluto and Neptune overlap, they are prevented from colliding by the 2-to-3 ratio in their rotations around the sun; Pluto goes around the sun in 247.94 earth years, and Neptune in 164.8, and $247.94/164.8$ equals 1.50449.... This kind of mutually influenced periodicity, as it turns out (how was I an astrologer for thirty years without learning this?), is common among pairs, trios, quadruples of planets, moons, asteroids, and so on, and is called *orbital resonance*. Three of the moons of Jupiter exhibit rotational ratios of 1:2:4, and there's even an asteroid that has a 5:8 dance going with respect to the earth. This is truly the harmony of the spheres, the surprisingly simple mathematical relations that planets in a rotational system fall into in response to each other's gravity.

Chalk it up to my personal eccentricities that this suddenly gave me a new way to compose. For 35 years I'd been writing repeating cycles at different tempos, and it has sometimes been an aesthetic problem for me when the articulation points of those cycles coincide by chance. But the solution, as it turned out, was already in our stars. Inspired by this new knowledge, I started using much simpler ratios than I had been using (3:4, 5:6:7 instead of 17:19:23), but shifting each one a slight amount so that the articulated beats would *never* coincide. It gave me a new way to create melody from the articulated beats among the different cycles. I immediately started a piece titled *Orbital Resonance*.

Orbital Resonance is for three computer-controlled pianos (Disklaviers, for instance), retuned to include 33 pitches to the octave, the result of eight harmonic series' on the first eight odd-numbered harmonics of Eb. Although the piece is fairly continuous within its moment form, its successive panels fall into six sections whose progression makes the derivation of the characteristic rhythm increasingly clear:

1. Articulation of the characteristic rhythm by various pitches in the scale less than a quarter-tone apart, with harmonizations (taking advantage of where such pitches in the scale differ by less than a quarter-tone) (mm. 1-103).
2. Articulation of the characteristic rhythm by dyads from different harmonic series' (mm. 103-132).
3. The characteristic rhythm fused into a single melody, accompanied by chords outlining the rhythmic derivation (mm. 133-191).
4. Articulation of the characteristic rhythm by widely-spaced sonorities separated by extremely parsimonious voice-leading (expansion of the 1st section and 2nd section ideas) (mm. 192-249).
5. Articulation of the characteristic rhythm divided out among increasingly audible independent melodic ostinatos (expansion of the 3rd section idea) (mm. 249-273).

6. A coda returning to the initial idea, with sparser harmonization (mm. 274-301).

This is a kind of broken symmetry characteristic of my music: the first section is paralleled with the sixth, the fourth combines the first and second, and the fifth expands on the third. I provide the plan not to suggest that the piece should be heard in a corresponding way, but merely to draw attention to the presence of an internal logic that might not be immediately evident.

For years I'd been trying to write something more elaborate both microtonally and polyrhythmically (and polytonally) than *Custer and Sitting Bull* (1999), and this is it: Nancarrow fused with Ben Johnston and La Monte Young with a dash of *Piano Phase* thrown in. And as with *Custer*, I've dedicated it to Ben, who in 1984 started me down this incredibly labor-intensive road.

- Kyle Gann
August, 2015
Germantown, NY

Technical Specifications

The 33-pitch tuning of the three pianos (the same in every octave) is as follows, given first in the number of cents above E-flat, and then as ratios to the E-flat 1/1:

Piano	1		2		3	
D	1088	15/8	977	225/128	1044	117/64
Db	969	7/4	938	55/32	906	27/16
C	857	105/64	773	25/16	840	13/8
B	738	49/32	755	99/64	729	195/128
Bb	702	3/2	590	45/32	609	91/64
A	551	11/8	551	11/8	481	169/128
Ab	471	21/16	440	165/128	408	81/64
G	386	5/4	320	77/64	342	39/32
Gb	204	9/8	275	75/64	275	75/64
F	155	35/32	192	143/128	192	143/128
E	92	135/128	53	33/32	27	65/64
Eb	0	1/1	1103	121/64	1173	63/32

Note that no string needs to be raised higher than its natural tuning except for the B-flat on piano 1, which is 2¢ sharp (or if one prefers, 2¢ could be subtracted from all quantities).

For electronic realization of the piece, it can prove helpful to reconfigure the tuning as a reference pitch in cycles per second for each piano, and ratios derived from that standard:

Tuning pitch:	38.891 cps	36.7641 cps	38.2833 cps
D	15/8	225/121	13/7
Db	7/4	20/11	12/7
C	105/64	200/121	104/63
B	49/32	18/11	65/42
Bb	3/2	180/121	13/9
A	11/8	16/11	169/126
Ab	21/16	15/11	9/7
G	5/4	14/11	26/21
F#	9/8	150/121	25/21
F	35/32	13/11	143/126
E	135/128	12/11	65/63
Eb	1/1	1/1	1/1

In the configuration of certain tuning softwares, the following sequences might facilitate getting the required tuning:

Piano 1:

38.891 = Eb0

1/1, 135/128, 35/32, 9/8, 5/4, 21/16, 11/8, 3/2, 49/32, 105/64, 7/4, 15/8

Piano 2:

36.7641485 = Eb0

1/1, 12/11, 13/11, 150/121, 14/11, 15/11, 16/11, 180/121, 18/11, 200/121, 20/11, 225/121

Piano 3:

38.283333 = Eb0

1/1, 65/63, 143/126, 25/21, 26/21, 9/7, 169/126, 13/9, 65/42, 104/63, 12/7, 13/7

For purposes of analysis, the entire scale (which I refer to as my 8x8 scale) is given below, grouping its pitches into eight harmonic series' on the 1st, 3rd, 5th, 7th, 9th, 11th, 13th, and 15th harmonics of E-flat, and naming each pitch in a typographical equivalent of Ben Johnston's just-intonation notation:

Pitch name	Ratio	Cents	1/1	3/2	5/4	7/4	9/8	11/8	13/8	15/8
Db^^-	121/64	1103						11		
D	15/8	1088	15	5	3					1
Db13	117/64	1044					13		9	
C#+	225/128	977								15
Db7	7/4	969	7			1				
C^	55/32	938			11			5		
C+	27/16	906		9			3			
C7+	105/64	857				15				7
Cb13	13/8	840	13						1	
B	25/16	773			5					
Bb^	99/64	755					11	9		
Cb77+	49/32	738				7				
Bb13	195/128	729							15	13
Bb	3/2	702	3	1						
Bbb713	91/64	609				13			7	
A+	45/32	590		15	9		5			3
Ab^	11/8	551	11					1		
Abb1313	169/128	481							13	
Ab7+	21/16	471		7		3				
G^	165/128	440						15		11
G+	81/64	408					9			
G	5/4	386	5		1					
Gb13	39/32	342		13					3	
Gb7^	77/64	320				11		7		
F#+	75/64	275			15					5
F+	9/8	204	9	3			1			
Fb13^	143/128	192						13	11	
F7+	35/32	155			7	5				
E+	135/128	92					15			9
Eb^	33/32	53		11				3		
Eb13	65/64	27			13				5	
Eb	1/1	0	1							
Eb7+	63/32	1173				9	7			

In Johnston's notation, + raises a pitch by 81/80, # raises it by 25/24, b lowers it by 24/25, 7 lowers it by 35/36, ^ raises it by 33/32, 13 raises it by 65/64, and F-A-C, C-E-G, and G-B-D are all perfectly tuned 4:5:6 major triads.

to Ben Johnston

Orbital Resonance

Kyle Gann
2015

♩ = 100

Piano 2

mp

Piano 3

mp

6

Pno2

Pno3

10

Pno2

Pno3

14

Pno2

Pno3

18

Pno2

Pno3



22

Pno1

Pno2

Pno3

26

Piano score for measures 26-28. The score is divided into three systems: Pno1, Pno2, and Pno3.

- Pno1:** Treble clef. Measures 26-28 feature a complex texture with triplets of eighth notes in the right hand and eighth notes in the left hand. A dynamic marking of *mp* is present in measure 27.
- Pno2:** Treble clef. Measures 26-28 feature a melodic line with triplets of eighth notes. The bottom two staves of this system are empty.
- Pno3:** Treble clef. Measures 26-28 feature a single melodic line with a long slur across all three measures.



29

Piano score for measures 29-31. The score is divided into two systems: Pno1 and Pno2.

- Pno1:** Treble clef. Measures 29-31 feature a complex texture with triplets of eighth notes in the right hand and eighth notes in the left hand.
- Pno2:** Treble clef. Measures 29-31 feature a melodic line with triplets of eighth notes. A dynamic marking of *mp* is present in measure 29.

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32

Pno1

Pno2

This musical system covers measures 32, 33, and 34. It features two piano parts, Pno1 and Pno2. Pno1 consists of three staves: the top staff has a treble clef and contains a melodic line with eighth-note triplets and slurs; the middle staff has a bass clef and contains a harmonic accompaniment with chords and slurs; the bottom staff has a treble clef and contains a bass line with eighth-note triplets and slurs. Pno2 also consists of two staves: the top staff has a treble clef and contains a melodic line with eighth-note triplets and slurs; the bottom staff has a bass clef and contains a harmonic accompaniment with chords and slurs. The key signature has one sharp (F#) and the time signature is 3/4.



35

Pno1

Pno2

This musical system covers measures 35, 36, and 37. It features two piano parts, Pno1 and Pno2. Pno1 consists of three staves: the top staff has a treble clef and contains a melodic line with eighth-note triplets and slurs; the middle staff has a bass clef and contains a harmonic accompaniment with chords and slurs; the bottom staff has a treble clef and contains a bass line with eighth-note triplets and slurs. Pno2 also consists of two staves: the top staff has a treble clef and contains a melodic line with eighth-note triplets and slurs; the bottom staff has a bass clef and contains a harmonic accompaniment with chords and slurs. The key signature has one sharp (F#) and the time signature is 3/4.

The musical score is divided into two systems, Pno1 and Pno2. Pno1 consists of three staves: a treble clef staff with eighth-note triplets, a bass clef staff with chords and triplets, and a middle staff with eighth-note triplets. Pno2 consists of four staves: a treble clef staff with chords and triplets, a bass clef staff with chords and triplets, a bass clef staff with a melodic line and slurs, and a bass clef staff with a melodic line and slurs. Dynamics include *mp* and *ff*. The score includes various musical notations such as slurs, triplets, and dynamic markings.

42

Pno1

Pno2

The musical score is divided into two systems, Pno1 and Pno2. Pno1 consists of four staves: two treble clefs and two bass clefs. The first two staves of Pno1 contain long, sustained notes with slurs. The last two staves of Pno1 contain a rhythmic pattern of eighth notes with slurs and repeat signs. Pno2 also consists of four staves: two treble clefs and two bass clefs. The first two staves of Pno2 contain long, sustained notes with slurs. The last two staves of Pno2 contain a rhythmic pattern of eighth notes with slurs and repeat signs. The score includes dynamic markings such as *mp* and repeat signs (double vertical lines with a brace).

47

Musical score for measures 47-50. The score is divided into three piano parts: Pno1, Pno2, and Pno3. Pno1 is in the bass clef, Pno2 in the treble clef, and Pno3 in the bass clef. The key signature has one sharp (F#). Pno1 and Pno3 play a rhythmic pattern of eighth notes with slurs and repeat signs. Pno2 has a melodic line in the upper staff and a harmonic accompaniment in the lower staff. A dynamic marking of *mp* is present in the upper staff of Pno2 at measure 49.



51

Musical score for measures 51-54. The score continues with Pno1, Pno2, and Pno3. The rhythmic patterns and slurs are consistent with the previous section. The melodic line in Pno2's upper staff continues with eighth notes and slurs.

55

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a piano (Pno1, Pno2, Pno3). The key signature is G major (one sharp) and the time signature is 4/4. Measure 55 is indicated at the top left. Pno1 (Piano 1) has a treble and bass staff. Pno2 (Piano 2) has two treble and two bass staves. Pno3 (Piano 3) has a treble and bass staff. The score includes various musical notations such as rests, eighth notes, quarter notes, and chords, with dynamic markings like '11' and '9'.

60

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). The first system (Pno1) starts at measure 60 and features a melodic line in the right hand with grace notes and a dynamic marking of *mp*. The second system (Pno2) features a complex rhythmic pattern in the right hand with grace notes. The third system (Pno3) features a melodic line in the right hand with grace notes and a dynamic marking of *mp*. The bass lines for all three pianos are mostly silent, indicated by rests.

66

Pno1

Pno2

Pno3



71

Pno1

Pno2

Pno3

76

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3).
- **Pno1:** The top two staves (treble clef) feature a 9-note chord in the first measure, which is sustained across the next four measures. The bottom two staves (bass clef) play a rhythmic pattern of eighth and sixteenth notes.
- **Pno2:** The top staff (treble clef) has a 9-note chord in the first measure, followed by a melodic line of eighth notes. The bottom staff (bass clef) is mostly silent, with some notes in the second and third measures.
- **Pno3:** The top two staves (treble clef) feature a complex 8-note chord in the first measure, sustained across the next four measures. The bottom staff (bass clef) plays a melodic line of eighth notes.

82

Pno1

Pno2

Pno3

The musical score consists of three parts: Pno1, Pno2, and Pno3. Pno1 is the most complex, with four staves. The top two staves are in treble clef, and the bottom two are in bass clef. Pno2 has a single bass clef staff. Pno3 has two staves, both in bass clef. The score begins at measure 82. Pno1's top staff features a melodic line with eighth and sixteenth notes, often beamed together. Pno1's bottom two staves provide a rhythmic accompaniment with eighth and sixteenth notes. Pno2 plays a steady, rhythmic pattern of eighth notes. Pno3 provides a bass line with eighth and sixteenth notes, often beamed together. The key signature has one sharp (F#) and one flat (Bb), and the time signature is 4/4.

87

Pno1

Pno2

Pno3

mf

mf

mf

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91

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a different piano (Pno1, Pno2, Pno3). The first system (Pno1) starts at measure 91 and features a complex melodic line with many accidentals and slurs. The second system (Pno2) continues the melodic line and includes a '9' marking under a slur, indicating a specific rhythmic or melodic pattern. The third system (Pno3) has a simpler melodic line with some accidentals. The score is written in treble and bass clefs across multiple staves.

95

Pno1

Pno2

Pno3

99

Pno1

Pno2

Pno3

The score consists of three systems, each for a piano. The first system (Pno1) starts at measure 99. The top staff has a complex melodic line with many accidentals and slurs. The middle staff has a similar melodic line. The bottom two staves have sustained chords. The second system (Pno2) features a melodic line with many accidentals and slurs, with a trill in the final measure. The third system (Pno3) features a melodic line with many accidentals and slurs, with a trill in the final measure. Dynamics include *p* (piano) and *p* (piano).

103 Musical score for three pianos (Pno1, Pno2, Pno3) starting at measure 103. The score is in 3/4 time and features complex rhythmic patterns, including triplets, quintuplets, and septuplets. Dynamics range from piano (p) to mezzo-forte (mf). The piece concludes at measure 117 with a final chord marked with a fermata and a repeat sign.

106

Pno1

5

5

p 3 3 3 3 3

p 5 5 5

p 7 7

Pno2

11

11

p 3 3 3

p 5 5 5 5

p 7 7

Pno3

p 3

p 5 5 5 5

p 7 7

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains five staves: two for the right hand and three for the left hand.
 - **Pno1:** Starts at measure 108. The right hand has chords with fingerings 5 and 9. The left hand has chords with fingerings 3 and 5, and a bass line with a 7-fingered chord.
 - **Pno2:** Features a 3-fingered chord in the right hand and a 5-fingered chord in the left hand.
 - **Pno3:** Includes a 3-fingered chord in the right hand and a 5-fingered chord in the left hand.
 - **Dynamic markings:** *mf* (mezzo-forte) is used in measures 108 and 113.
 - **Other markings:** *Ped.* (pedal) markings are present at the end of the first and second systems.
 - **Measure numbers:** 108, 11, 13, and 9 are indicated throughout the score.

113

Pno1

Pno2

Pno3

Detailed description: This musical score page, numbered 113, features three piano parts. Pno1 consists of three staves: the top staff has a sequence of chords with a bracketed interval of 5; the middle staff has a sequence of notes with a bracketed interval of 9; the bottom staff has a sequence of chords with a bracketed interval of 7. Pno2 consists of a single staff with a sequence of chords and a bracketed interval of 11. Pno3 consists of two staves: the top staff has a sequence of chords with a bracketed interval of 13; the bottom staff has a sequence of notes with a bracketed interval of 9. The score is written in treble clef with a key signature of one sharp (F#).

117

Musical score for Pno1, measures 117-119. The score consists of five staves. The top staff has a treble clef and contains chords with a bracket labeled '5' under each measure. The second staff has a treble clef and contains a melodic line with a bracket labeled '9' under the first two measures. The third staff has a bass clef and contains chords with a bracket labeled '7' under each measure. The fourth staff is empty. The fifth staff has a bass clef and contains a single note with a bracket labeled '7' under it. The dynamic marking 'mf' appears in the second and fifth staves.

Musical score for Pno2, measures 117-119. The score consists of two staves. The top staff has a treble clef and contains chords with a bracket labeled '11' under each measure. The bottom staff is empty. The dynamic marking 'mf' appears in the bottom staff at the end of measure 119.

Musical score for Pno3, measures 117-119. The score consists of four staves. The top staff has a treble clef and contains chords with a bracket labeled '13' under each measure. The second staff is empty. The third staff has a treble clef and contains a melodic line with a bracket labeled '9' under the first two measures. The fourth staff has a bass clef and contains a single note with a bracket labeled '7' under it. The dynamic marking 'mf' appears in the second and fourth staves.

120

Pno1

Pno2

Pno3

5

13

Detailed description: This page of a musical score contains measures 120 through 123 for three piano parts. Pno1 (top) begins with a 5-measure chord in the first measure, followed by a melodic line in the second measure and rests in the third and fourth. Pno2 (middle) plays a continuous melodic line across all four measures. Pno3 (bottom) features a 13-measure chord in the first measure, followed by a melodic line in the second measure and rests in the third and fourth. The score is written in treble and bass clefs with various accidentals and articulation marks.

124

Piano score for measures 124-126. The score is divided into three systems: Pno1, Pno2, and Pno3. Pno1 consists of three staves (treble, bass, and a second treble). Pno2 consists of one staff (treble). Pno3 consists of two staves (treble and bass). The music features complex textures with many notes, some beamed together, and various articulations like slurs and accents.



127

Piano score for measures 127-130. The score is divided into three systems: Pno1, Pno2, and Pno3. Pno1 consists of three staves (treble, bass, and a second treble). Pno2 consists of one staff (treble). Pno3 consists of two staves (treble and bass). The music continues with complex textures, including slurs and accents.

130

Pno1

Pno2

Pno3

133 $\text{♩} = 180$

Pno1

mf

mp

mp

7

7

Pno2

mf

mp

5

Pno3

$\text{♩} = 180$

mp

137

Pno1

Musical score for Pno1, measures 137-140. The score consists of five staves. The top two staves are treble clef, and the bottom three are bass clef. The music features a complex texture with many sixteenth notes and slurs. The bass line includes fingerings 5 and 7.

Pno2

Musical score for Pno2, measures 137-140. The score consists of three staves. The top two are treble clef, and the bottom is bass clef. The music features a complex texture with many sixteenth notes and slurs. The bass line includes a fingering 5.

Pno3

Musical score for Pno3, measures 137-140. The score consists of a single treble clef staff. The music features a complex texture with many sixteenth notes and slurs.

Orbital Resonance

141

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3).
- **Pno1:** Starts at measure 141 with a complex melodic line in the right hand, featuring many sixteenth notes and slurs. The left hand has a bass line with a 5-fingered chord in the first measure and a 7-fingered chord in the second measure. There are also some rests in the left hand.
- **Pno2:** Starts with a key signature change to one sharp (F#). The right hand has a melodic line with many sixteenth notes and slurs. The left hand has a melodic line with slurs and some rests.
- **Pno3:** The right hand has rests for the first three measures, then enters with a melodic line. The left hand has a bass line with chords and a melodic line with chords.

145

Pno1

Pno3

The image shows a musical score for two piano parts, Pno1 and Pno3, spanning measures 145 to 148. Pno1 consists of five staves: two treble clefs and three bass clefs. The top two staves contain melodic lines with eighth and sixteenth notes, often beamed together. The bottom three staves provide harmonic support with chords and bass lines, including a prominent 7th fret barre in the lowest bass staff. Pno3 consists of four staves: two treble clefs and two bass clefs. The top two staves have sparse melodic entries, while the bottom two staves feature sustained chords and bass lines, with a 5th fret barre in the lowest bass staff. The score is written in a key with one sharp (F#) and a common time signature.

148

Pno1

Pno2

Pno3

Detailed description of the musical score: The score is for three piano parts. Pno1 (top) and Pno3 (bottom right) are in treble clef, while Pno2 (middle) is in bass clef. The music begins at measure 148. Pno1 features a complex melodic line with many slurs and ties. Pno2 has a more rhythmic, bass-oriented line with some slurs and fingerings of 7. Pno3 has a melodic line with many slurs and ties, and a bass line with fingerings of 5. The notation includes various note values, rests, and articulation marks.

151

Pno1

Pno2

Pno3

The musical score is divided into three piano parts. Pno1 consists of three staves. The top staff features a melodic line with eighth-note patterns and slurs. The middle staff continues the melodic line with some chromaticism. The bottom staff provides a harmonic accompaniment with chords and eighth-note patterns. Pno2 consists of a single bass staff that is mostly empty, with a few notes at the beginning and rests for the remainder of the section. Pno3 consists of four staves. The top two staves have sparse melodic lines with slurs. The third staff contains sustained chords. The bottom staff features a bass line with a quintuplet marked with a '5' and a slur, followed by other notes and slurs.

154

Pno1

Pno2

Pno3

♩ = 100

156

Pno1

Pno2

Pno3

f

5

158

Pno1

Pno2

Pno3

Orbital Resonance

160

Pno1

Pno2

Pno3

5

7

7

5

5

Orbital Resonance

163 ♩ = 100

Pno1

mf

mp

mp

Pno2

mf

mp

mf

Pno3

♩ = 100

mf

mp

166

Pno1

Pno2

Pno3

Detailed description of the musical score: The score is for three piano parts, labeled Pno1, Pno2, and Pno3. It begins at measure 166. Pno1 consists of a treble and bass staff. The treble staff features a melodic line with eighth and sixteenth notes, often beamed together, and some slurs. The bass staff provides a harmonic accompaniment with longer note values and slurs. Pno2 also has a treble and bass staff. The treble staff has a more active melodic line with frequent sixteenth-note patterns, while the bass staff has a steady eighth-note accompaniment. Pno3 has a treble and bass staff. The treble staff is mostly silent with occasional notes, while the bass staff has a simple, rhythmic accompaniment. The key signature has one flat (B-flat), and the time signature is 3/4.

169 $\text{♩} = 120$

Pno1

Pno2

Pno3

mf

mf

$\text{♩} = 120$

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172

Pno1

Pno2



176

Pno1

Pno2

180 ♩ = 140

Pno1

mp

Pno2

mp

mp

Pno3

mp

mp

The musical score consists of three systems. The first system is for Pno1, the second for Pno2, and the third for Pno3. Each system contains three staves. Pno1 and Pno2 are in treble clef, while Pno3 is in bass clef. The tempo is 180, with a quarter note equal to 140. The music is marked mezzo-piano (mp). The score features complex rhythmic patterns, including sixteenth and thirty-second notes, and various articulations like slurs and accents.

184

The musical score is divided into three systems, each labeled on the left as Pno1, Pno2, and Pno3. The first system (Pno1) consists of three staves: a top staff with a treble clef and a whole rest, a middle staff with a treble clef and a series of chords and notes, and a bottom staff with a treble clef and a series of notes. The second system (Pno2) also has three staves: a top staff with a treble clef and notes with ornaments, a middle staff with a treble clef and notes, and a bottom staff with a treble clef and notes. The third system (Pno3) has three staves: a top staff with a treble clef and notes with ornaments, a middle staff with a treble clef and notes, and a bottom staff with a bass clef and notes. The music is in a key with one sharp (F#) and a common time signature.

188

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a piano (Pno1, Pno2, Pno3). Each system contains four staves. Pno1 and Pno3 have a treble and bass staff, while Pno2 has a treble and bass staff. The music is in 2/4 time and starts at measure 188. It features complex textures with many accidentals and slurs. The score includes various rhythmic patterns, including eighth and sixteenth notes, and rests. A key signature change to one flat is indicated at the end of the system.

192 $\text{♩} = 100$

Pno1

Pno2

$\text{♩} = 100$

Pno3

Pno1

Musical score for Pno1, measures 196-200. The score is written for four staves: Treble, Treble, Bass, and Bass. It features complex rhythmic patterns with many rests and slurs. The key signature has one flat (B-flat) and the time signature is 4/4. The notation includes various note values, rests, and slurs across all staves.

Pno2

Musical score for Pno2, measures 196-200. The score is written for four staves: Treble, Treble, Bass, and Bass. It features complex rhythmic patterns with many rests and slurs. The key signature has two sharps (F# and C#) and the time signature is 4/4. The notation includes various note values, rests, and slurs across all staves.

Pno3

Musical score for Pno3, measures 196-200. The score is written for four staves: Treble, Treble, Bass, and Bass. It features complex rhythmic patterns with many rests and slurs. The key signature has one flat (B-flat) and the time signature is 4/4. The notation includes various note values, rests, and slurs across all staves.

Pno1

Musical score for Pno1, consisting of four staves. The top staff is a single treble clef line. The second and third staves are a grand staff (treble and bass clefs). The bottom staff is a single bass clef line. The music features complex rhythmic patterns, including sixteenth and thirty-second notes, and various articulations like slurs and accents.

Pno2

Musical score for Pno2, consisting of four staves. The top staff is a single treble clef line. The second and third staves are a grand staff (treble and bass clefs). The bottom staff is a single bass clef line. The music features complex rhythmic patterns, including sixteenth and thirty-second notes, and various articulations like slurs and accents.

Pno3

Musical score for Pno3, consisting of four staves. The top staff is a single treble clef line. The second and third staves are a grand staff (treble and bass clefs). The bottom staff is a single bass clef line. The music features complex rhythmic patterns, including sixteenth and thirty-second notes, and various articulations like slurs and accents.

203

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a piano (Pno1, Pno2, Pno3). Each system contains four staves: a single treble clef staff at the top and three bass clef staves below it. The music is written in a key signature of one flat (B-flat) and a 3/4 time signature. Measure 203 is indicated at the beginning of the first system. The notation includes various note values (quarter, eighth, and sixteenth notes), rests, and dynamic markings such as *mf* and *ff*. There are also slurs and phrasing slurs throughout the piece. The score is complex, with many notes beamed together and some notes marked with accents or breath marks.

209

Pno1

Pno2

Pno3

mf

mf

mf

Orbital Resonance

212

Pno1

Pno2

Pno3

Orbital Resonance

214

Pno1

Musical score for Pno1, measures 214-217. The score consists of four staves: two treble clefs and two bass clefs. The first treble staff contains sustained chords with a flat key signature. The second treble staff features a rhythmic pattern of eighth notes with a '7' (pedal point) marking. The first bass staff has a flat key signature and sustained chords. The second bass staff contains a sequence of notes with a sharp key signature and a '7' marking.

Pno2

Musical score for Pno2, measures 214-217. The score consists of three staves: two treble clefs and one bass clef. The first treble staff has sustained chords. The second treble staff has a rhythmic pattern of eighth notes with a '7' marking. The bass staff is mostly empty, with a few notes in the second measure.

Pno3

Musical score for Pno3, measures 214-217. The score consists of five staves: two treble clefs, one bass clef, and two additional staves. The first two treble staves have sustained chords. The first bass staff has a flat key signature and sustained chords. The second treble staff has a rhythmic pattern of eighth notes with a '7' marking. The second bass staff has a sequence of notes with a sharp key signature and a '7' marking. The bottom-most staff has a sequence of notes with a flat key signature.

216 51

Pno1

Pno2

Pno3

Orbital Resonance

218

Pno1

Pno2

Pno3

221 53

Pno1

Pno2

Pno3

The image displays a musical score for three pianos, labeled Pno1, Pno2, and Pno3. The score is divided into two systems, with measures 221 and 53 indicated at the top. Each piano part consists of a treble and a bass staff. Pno1 features complex rhythmic patterns with many sixteenth notes and rests, often grouped with slurs and dynamic markings. Pno2 has a more melodic line in the treble and a bass line with rhythmic accompaniment. Pno3 provides a harmonic foundation with sustained chords and moving bass lines. The notation includes various accidentals, slurs, and dynamic markings throughout the piece.

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains multiple staves. Pno1 and Pno3 have four staves each, while Pno2 has three. The notation includes treble and bass clefs, various note values (quarter, eighth, sixteenth notes), rests, and dynamic markings. Pno1 features complex rhythmic patterns with many beamed notes and slurs, including several '7' markings. Pno2 has a more melodic line with some slurs and rests. Pno3 features a steady accompaniment with slurs and rests. The score is written in a key with one sharp (F#) and a time signature of 7/8.

225

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains multiple staves. Pno1 has five staves, Pno2 has three staves, and Pno3 has three staves. The notation includes treble and bass clefs, various note values, rests, and dynamic markings. Pno1 features a complex rhythmic pattern in its bass line with frequent accidentals and slurs. Pno2 and Pno3 have more sustained, chordal textures with some melodic lines. The score is marked with measure numbers 225, 226, 227, and 228. The key signature has one sharp (F#) and the time signature is 4/4.

227

The image displays a musical score for three pianos, labeled Pno1, Pno2, and Pno3. The score is organized into three systems, each corresponding to one of the pianos. Each system contains multiple staves: Pno1 has five staves, Pno2 has four staves, and Pno3 has three staves. The music is written in treble and bass clefs. The key signature is one sharp (F#), and the time signature is 7/8. The score shows measures 227, 228, and 229. Dynamic markings include *mf* (mezzo-forte). Fingering numbers, such as '5', are indicated above certain notes. The notation includes various rhythmic values, slurs, and articulation marks.

Pno1

Musical score for Pno1, consisting of three staves. The top staff is in treble clef with a key signature of one flat (Bb) and contains a melodic line with slurs and a fermata. The middle staff is in treble clef and contains a line with a '5' fingering and slurs. The bottom staff is in bass clef and contains a bass line with slurs and a fermata.

Pno2

Musical score for Pno2, consisting of four staves. The top staff is in treble clef with a key signature of two sharps (F#C#) and contains a melodic line with slurs. The second staff is in treble clef and contains a complex texture with many notes and slurs. The third staff is in treble clef and contains a line with a '5' fingering and slurs. The bottom staff is in bass clef and contains a bass line with slurs.

Pno3

Musical score for Pno3, consisting of three staves. The top staff is in treble clef with a key signature of two sharps (F#C#) and contains a melodic line with slurs. The middle staff is in treble clef and contains a line with a '5' fingering and slurs. The bottom staff is in bass clef and contains a bass line with slurs and a fermata.

Pno1

Pno2

Pno3

236

Pno1

Musical score for Pno1, measures 236-238. The score consists of five staves. The top staff is in treble clef with a key signature of one flat (B-flat). The second staff is in treble clef with a key signature of one sharp (F#). The third staff is in treble clef with a key signature of one flat (B-flat) and contains a five-fingered scale marked with a '5'. The fourth and fifth staves are in bass clef with a key signature of one flat (B-flat). The music features complex rhythmic patterns and melodic lines across all staves.

Pno2

Musical score for Pno2, measures 236-238. The score consists of five staves. The top staff is in treble clef with a key signature of one sharp (F#). The second staff is in treble clef with a key signature of one sharp (F#) and contains a five-fingered scale marked with a '5'. The third and fourth staves are in treble clef with a key signature of one sharp (F#). The fifth staff is in bass clef with a key signature of one sharp (F#). The music features complex rhythmic patterns and melodic lines across all staves.

Pno3

Musical score for Pno3, measures 236-238. The score consists of three staves. The top staff is in treble clef with a key signature of one sharp (F#). The middle staff is in treble clef with a key signature of one sharp (F#) and contains a five-fingered scale marked with a '5'. The bottom staff is in bass clef with a key signature of one flat (B-flat). The music features complex rhythmic patterns and melodic lines across all staves.

Orbital Resonance

239

Pno1

Pno2

Pno3

242

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano part.
 - **Pno1** (top system) consists of four staves. The top staff features a complex, dense texture of chords and arpeggios. The second staff has a melodic line with long notes and ties. The third and fourth staves provide a rhythmic bass line with eighth-note patterns.
 - **Pno2** (middle system) consists of three staves. The top staff has a melodic line with some rests. The middle and bottom staves are mostly silent, with only a few notes at the beginning.
 - **Pno3** (bottom system) consists of three staves. The top staff has a complex texture of chords. The middle staff has a melodic line with long notes. The bottom staff has a rhythmic bass line with eighth-note patterns.

245

Pno1

Pno2

Pno3

The musical score consists of three piano parts. Pno1 is the most complex, featuring three staves: a treble staff with dense chordal textures and arpeggiated figures, a bass staff with a steady eighth-note accompaniment, and a lower bass staff with a similar eighth-note pattern. Pno2 is a single treble staff with a melodic line of quarter and eighth notes. Pno3 consists of a treble staff with a melodic line and a bass staff with a steady eighth-note accompaniment. The score is marked with measure numbers 245, 246, and 247.

Pno1

Musical score for Pno1, consisting of four staves. The top staff is a grand staff (treble and bass clefs) with a complex texture of chords and arpeggios, marked *mp*. The second staff is a single treble clef staff with a melodic line. The third and fourth staves are bass clef staves with a rhythmic accompaniment of eighth notes.

Pno2

Musical score for Pno2, consisting of four staves. The top two staves are treble clef staves with melodic lines, marked *mf*. The bottom two staves are bass clef staves with a complex texture of chords and arpeggios, marked *mp*.

Pno3

Musical score for Pno3, consisting of four staves. The top staff is a grand staff (treble and bass clefs) with a complex texture of chords and arpeggios, marked *mf*. The second staff is a single treble clef staff with a melodic line. The third and fourth staves are bass clef staves with a rhythmic accompaniment of eighth notes.

251

Pno1

Pno2

Pno3

The musical score consists of three parts: Pno1, Pno2, and Pno3. Pno1 is written on a single staff with a treble clef and a key signature of one flat. It features a melodic line with slurs and dynamic markings. Pno2 is written on two staves, both with treble clefs and a key signature of one sharp. The upper staff has a melodic line with slurs and dynamic markings, while the lower staff has a bass line with chords and slurs. Pno3 is written on a single staff with a treble clef and a key signature of one sharp, featuring a bass line with chords and slurs. The score is marked with measure numbers 251, 252, 253, and 254.

254

Pno1

Pno2

Pno3

257

Pno1

mf

mf

mp

mp

Musical score for Pno1, measures 257-259. The score consists of four staves: two treble clefs and two bass clefs. The first two staves have a dynamic marking of *mf*. The third staff has a dynamic marking of *mp*. The fourth staff has a dynamic marking of *mp*. The music features a mix of eighth and sixteenth notes, with some notes beamed together.

Pno2

mf

mp

mp

Musical score for Pno2, measures 257-259. The score consists of four staves: two treble clefs and two bass clefs. The first two staves have a dynamic marking of *mf*. The third staff has a dynamic marking of *mp*. The fourth staff has a dynamic marking of *mp*. The music features a mix of eighth and sixteenth notes, with some notes beamed together.

Pno3

mf

mp

Musical score for Pno3, measures 257-259. The score consists of three staves: one treble clef and two bass clefs. The first staff has a dynamic marking of *mf*. The second and third staves have a dynamic marking of *mp*. The music features a mix of eighth and sixteenth notes, with some notes beamed together.

260

Pno1

Pno2

Pno3

Orbital Resonance

263

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a different piano (Pno1, Pno2, Pno3). Each system has four staves: two treble clefs and two bass clefs. The music is in 3/4 time. Pno1 features a complex rhythmic pattern in the upper staves and sustained chords in the lower staves. Pno2 has a similar rhythmic pattern in the upper staves and sustained chords in the lower staves. Pno3 has a simpler rhythmic pattern in the upper staves and sustained chords in the lower staves. The score is marked with measure numbers 263, 264, 265, and 266. The key signature has one flat (B-flat).

Orbital Resonance

266

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a piano (Pno1, Pno2, Pno3). Each system has four staves (treble and bass clefs).
- **Pno1:** Measures 266-267 show a melodic line in the upper register and a bass line. Measures 268-269 have rests for the upper register, with a 7-measure rest in the bass line. Dynamics include *p*.
- **Pno2:** Measures 266-267 show a melodic line in the middle register and a bass line. Measures 268-269 continue the melodic line. Dynamics include *mp*.
- **Pno3:** Measures 266-267 show a melodic line in the upper register and a bass line. Measures 268-269 have rests for the upper register, with a 7-measure rest in the bass line. Dynamics include *p*.

270

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a piano (Pno1, Pno2, Pno3).
- **Pno1:** Starts at measure 270 with a complex chordal texture. The right hand features a series of chords with 7-fingerings indicated by brackets. The left hand is mostly silent, with a few notes appearing at the end of the system. A dynamic marking of *p* is present.
- **Pno2:** Features a melodic line in the right hand with chromatic movement and slurs. The left hand plays a supporting bass line with chords and slurs. A dynamic marking of *p* is present.
- **Pno3:** Features a melodic line in the right hand with 7-fingerings indicated by brackets. The left hand is mostly silent, with a few notes appearing at the end of the system.

275

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains multiple staves. Pno1 has three staves, Pno2 has five staves, and Pno3 has three staves. The music is written in treble and bass clefs. Measure 275 is marked at the beginning. Dynamic markings include *p* (piano) and *mf* (mezzo-forte). There are various musical notations such as slurs, ties, and accents throughout the score.

Orbital Resonance

279

Pno1

Pno2

Pno3

p

p

p

Orbital Resonance

283

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains multiple staves. Pno1 has four staves, Pno2 has five staves, and Pno3 has three staves. The notation includes various note values, rests, ties, and dynamic markings such as *p* (piano) and *f* (forte). The piece is titled "Orbital Resonance" at the bottom.

Orbital Resonance

287

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3).
- **Pno1:** Starts with a treble clef and a key signature of one flat. It features a melodic line with a slur over the first two measures and a dynamic marking of *p* in the second measure. The bass line consists of a steady eighth-note accompaniment.
- **Pno2:** Features a treble clef and a key signature of one sharp. The right hand has a complex rhythmic pattern of eighth notes with slurs. The left hand has a bass clef and provides harmonic support with chords and a melodic line.
- **Pno3:** Features a treble clef and a key signature of one sharp. The right hand has a melodic line with slurs. The left hand has a bass clef and provides harmonic support with chords and a melodic line.

291

Piano score for measures 291-294, featuring three piano parts (Pno1, Pno2, Pno3).



295

Piano score for measures 295-300, featuring three piano parts (Pno1, Pno2, Pno3).

July 15 - August 18, 2015
Germantown, NY

Orbital Resonance