MUSIC OF THE SPHERES **ver 1.2**

cosmic emulation synthesizer

USER'S GUIDE

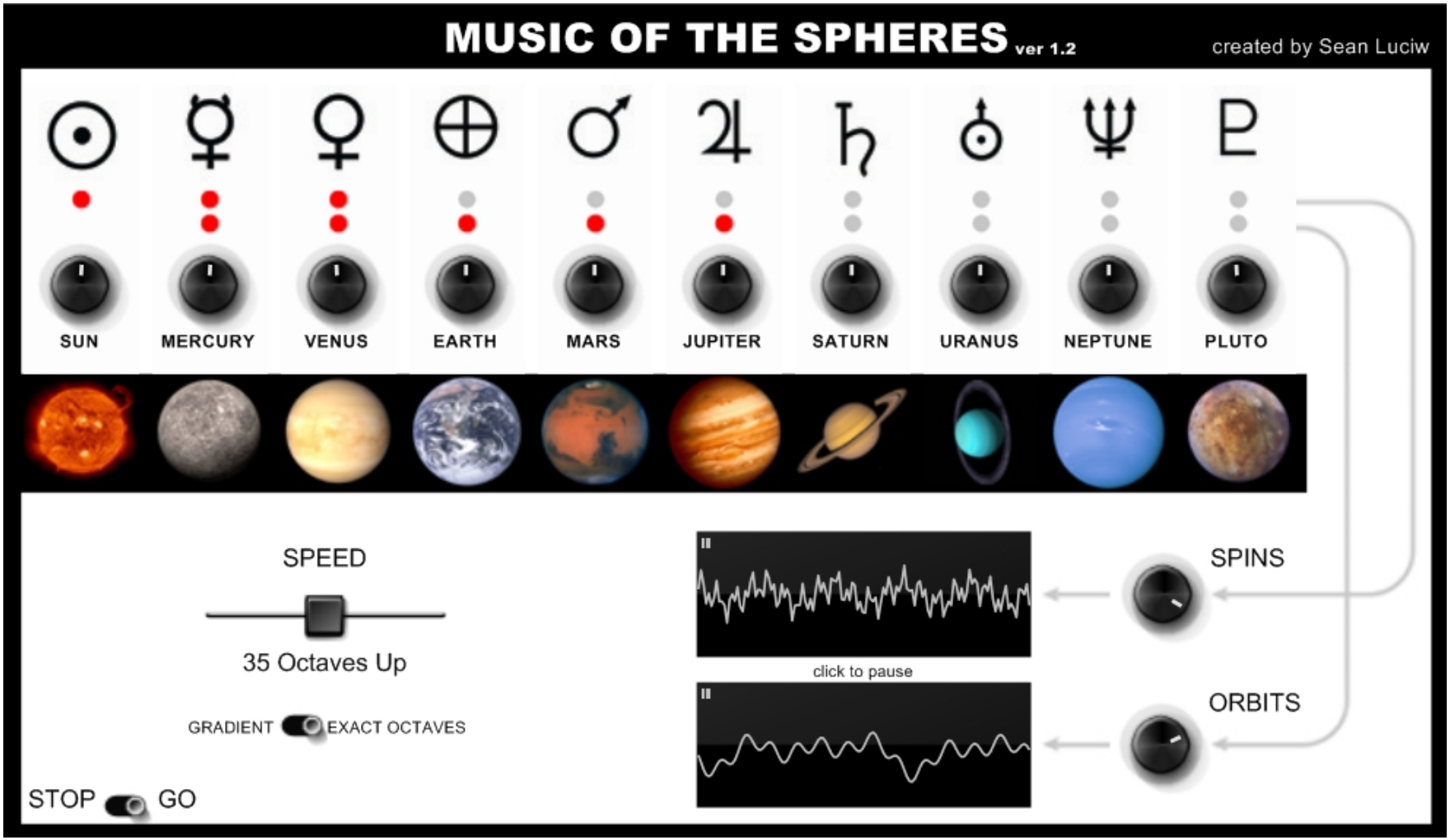


TABLE OF CONTENTS

MUSIC OF THE SPHERES ver 1.2

cosmic emulation synthesizer

standalone music software created by Sean Luciw
http://seanluciw.com
email: twistedmusictheory@gmail.com

Music Of The Spheres
version 1.2

created using Synthmaker 1.1.7

SYSTEM REQUIREMENTS

Processor: Pentium III/AMD with SSE support
Speed: 1200 MHz
Memory: 256 MB RAM
Operating system: Windows 7/Vista/2000/XP

DISCLAIMER

This software (Music Of The Spheres ver 1.2) is provided "as is" without warranty of any kind. The author makes no guarantee of correctness, accuracy, reliability, safety or performance. The user alone is responsible for determining if this software is safe for use in their environment. Neither the author nor anyone else who has been involved in the creation or delivery of this product shall be liable for any direct, indirect, consequential, or incidental injury or damages arising from the use or inability to use such product.

INSTALLATION

To install Music Of The Spheres ver 1.2, simply double-click the file *MusicOfTheSpheres_v1.2_Setup.exe* and follow the instructions.

On the last page of the install procedure, you will have a chance to view the .pdf version of this User's Guide. You will also see a checkbox prompting whether or not you want to launch the Music Of The Spheres program upon completion of the installation.

A shortcut to the program will be installed on the desktop. The Start menu will contain shortcuts to the program, the User's Guide and the Uninstaller.

UNINSTALLATION

If you decide to uninstall Music Of The Spheres for some reason, use the Uninstall shortcut in the Start menu.

LICENSE

Version 1.2 of the Music Of The Spheres program is donationware. Donations are gratefully accepted at http://seanluciw.com, where the program is also available for download.

INTRODUCTION

Our planet spins in a full 360 degree circle around its own axis once every 24 hours. Repetitive occurrences (such as spinning) automatically produce musical tones. So, the Earth is singing. However, its voice is so slow, and so low, that our tiny eardrums are unable to ride its wave. Just as a dog-whistle is too high-pitched for humans to hear, the Music Of The Spheres is too low.

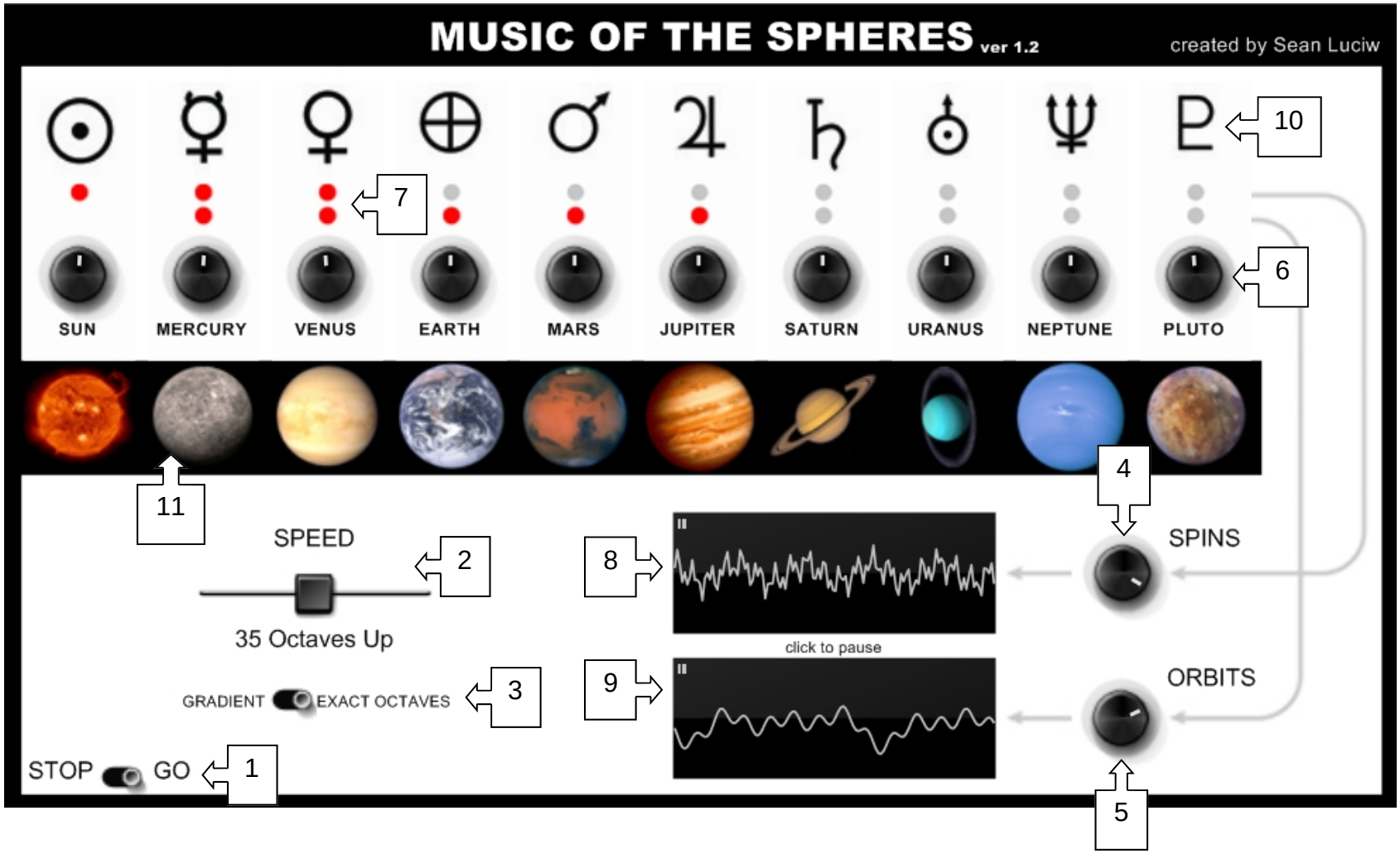
In musical composition and performance it is common practice to raise or lower the pitch of a melody, chord, or song without sacrificing the integrity of its internal structure and emotion. This is called transposition. A fun way of doing this is to adjust the speed slider of a vinyl record player: as the record is sped up, the notes and chords sound higher and higher. The melodies and chord will still be recognizable, even at a different pitch. If you put your finger on the record and gradually increase pressure, you can slow the music down until it is too low to hear and finally stops. This computer program changes the speed of the Solar System just like the speed slider of a record player.

After I learned that the orbits of Venus and Mars produce a musical power chord (the backbone of hard rock music and the seed of the entire chromatic scale), I envisioned a computer program that could deliver the tones of the planets, authentically proportioned, sped up so humans can hear them. There would be one main slider for adjusting the speed of the Solar System, and a few other user controls.

As with any creative project, the result is a little different from the original mental manifestation - I still have leftover ideas for future revisions and enhancements. For now, I hope you enjoy this cosmic emulation synthesizer.

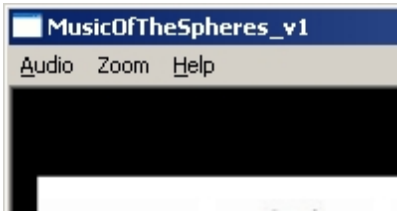
THE INTERFACE

(see next page for descriptions)



1	STOP/GO switch. To hear the Solar System sing, switch to GO. (select soundcard from Audio popdown menu first, see p. 9)
2	SPEED slider. To speed up the Solar System like a record player, slide it to the right. The range of this control is thorough; when it's all the way to the left (20 octaves higher than real speed), the entire Solar System is too low for humans to hear; when it's all the way to the right (50 octaves higher than real speed), it's too high for us to hear. Slide it to somewhere in the middle to hear the planets sing. It is not possible to hear all planets simultaneously.
3	GRADIENT / EXACT OCTAVES switch. When switched to EXACT OCTAVES, each planet will sing exactly the same note it sings in real life (an F-sharp note, for example), but transposed up however many octaves you specify by the SPEED slider. "In between" speeds are not possible. When switched to GRADIENT, you have access to a continuous rainbow of speed adjustment. Holding <SHIFT> at the same time will allow a finer degree of control.
4	SPINS volume knob. This controls the collective loudness of the sound produced by the planets spinning on their own axes.
5	ORBITS volume knob. This controls the collective loudness of the sound produced by the planets traveling around the Sun.
6	Volume knob for each planet. Turning a knob affects the loudness of that planet's ORBIT tone and SPIN tone simultaneously.
7	Audibility indicator lights. The top light indicates whether or not that planet's SPIN tone is within audible range. The bottom light indicates whether or not that planet's ORBIT tone is within audible range. Red means yes, grey means no.
8	SPINS graph. This is an oscilloscope-style visual representation of all SPIN tones which are being fed from each planet through the SPINS volume control. Click on the graph to pause the display, and click again to unpause.
9	ORBITS graph. This is an oscilloscope-style visual representation of all ORBIT tones which are being fed from each planet through the ORBITS volume control. Click on the graph to pause the display, and click again to unpause.
10	Mysterious looking planetary symbols.
11	Pretty pictures of the planets (thanks NASA).

DROPDOWN MENUS



There are 3 dropdown menus at the top of the screen:

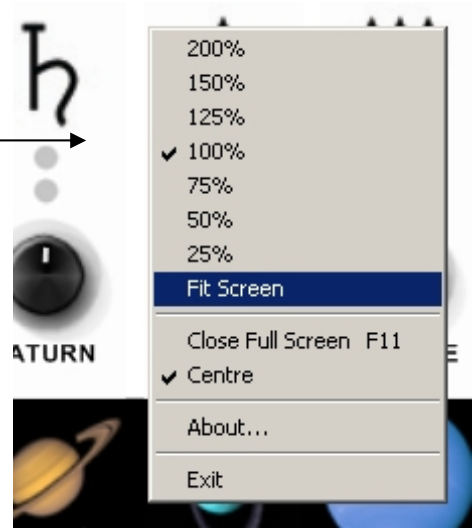
The Audio menu is where you select your soundcard. You'll need to select your soundcard before using the program.

The Zoom menu allows you to change the size of the metronome on the screen. You can change the size of the metronome from 25% (smaller) to 200% (larger).

The Help menu contains the About box.

RIGHT-CLICK MENU

In both normal screen and Full Screen mode, right-clicking with the mouse will bring up a menu: Zoom, Full Screen, About, and program Exit options are available.



DESIGN PHILOSOPHY

Music Of The Spheres version 1.2 was designed with accuracy in mind; therefore, I used actual data describing the orbital periods and rotation periods of the planets to determine the frequencies of audible notes, rather than mere approximations. What you hear is the real harmony of the Solar System! I did not attempt to adjust the harmonies to sound more pleasant by finding the next closest match to the musical intervals defined by the "Just Temperament" (interval-ratio) or "Equal Temperament" (popular standard) systems which our ears are so accustomed to. What you hear is the real deal.

The program has a switch labeled "gradient/exact octaves". When set to "exact octaves", all planetary data are simultaneously multiplied by 2^x, where x is an integer. In musical terms this is called octave transposition, and it means that a note will retain its "note class"; in other words, if a B-flat note has its frequency multiplied by 2, 4, 8, 16, 32, 64, 128, or some other such number, it will still sound like a B-flat note. I felt that preserving this aspect of the Solar System's musicality was an extremely important capability of the program. If the switch is set to "gradient", the user has a more continuous control - the ratios (harmonic intervals) of planetary movement are still preserved in relation to each other, but the note classes are not preserved.

Any circular motion can be plotted to a sinusoidal wave. All oscillators within the program are sine waves. However, the planets move in elliptical paths around the Sun, not circular; at one point in the development of the program, an extra oscillator was provided to modulate the sine wave produced by each planet's orbital period, as an attempt to imitate the eccentricity of orbital trajectories. However, the elliptical modulation seemed to have no perceptible effect on the tones, so the idea was ditched in favour of saving CPU cycles.

Apparently at some point in his quest to define the Music Of The Spheres, Johannes Kepler decided that, since the orbits do not follow perfectly circular paths (and their velocities are therefore not constant), that orbital data should be rejected as the defining criteria in the determination of celestial harmony. However, I insist - and I think this is obvious - that the elliptical shape does not pose a problem. The only effect is that the sine wave produced by an elliptical motion will be a little bit "lop-sided". That's okay. The important thing is that the length of each cycle is reliably constant, even if that cycle's shape is not perfectly sinusoidal. In fact, many different wave shapes are commonplace in the realm of music synthesis - sine, triangle, square, sawtooth...

In 2006, the International Astronomical Union demoted Pluto to dwarf-planet status. I created this computer program prior to Pluto's demotion, and so Pluto is present in the harmony. Even if the program is revised at some point in the future, I will probably continue to include Pluto because of my stubborn sentimental attachment. In a future version I may also choose to include other celestial bodies such as Ceres, Eris, Haumea, Makemake, Varuna, Quaoar, Chaos, Logos & Zoe, Teharonhiawako & Sawiskera, Deucalion, and other various cubewanos, asteroid clumps and moons.

QUESTIONS & ANSWERS

The Most Obvious Question: *"If the Solar System is making music, then what note is our home-planet Earth singing?"*

There are two answers:

1) one note is sung by virtue of the Earth's orbit around the Sun
2) one note is sung by the Earth's rotation on its own axis

Both answers require a bit of math, unless you have super-low hearing and a perfect sense of pitch.

Answer #1 (orbit):

Earth takes 8766.14 hours to travel around the Sun; convert this to seconds, because musical frequency is expressed in cycles-per-second:

8766.14 hours x 3600 seconds/hour = 31,558,104 seconds-per-cycle

Flip this number upside-down to find cycles-per-second:

1 ÷ 31,558,104 = 0.0000000316875817 cycles-per-second

This is the true frequency of Earth's orbit, which is way too low for us to hear. The next step is to transpose this frequency up several octaves into a range which is audible and can be compared to established musical frequencies. This is done by doubling the number several times (ie. multiplying by 2 to the power of some integer):

$0.00000003.16875817 \times 2^{33} = 272.19425418$ cycles-per-second

Thirty-three octaves was chosen because the range from "Equal Temperament middle C" up to its octave is in the range from 261.63 Hz to 523.26 Hz. The range of human hearing is much wider, but this range is convenient for comparison. The closest match from the Equal Temperament system is C#, with a frequency of 277.18 Hz.

So... *Earth's orbit sings a very low C-sharp!*

Is it perfectly in tune with your average piano? No, of course not - that would be too good to be true! So, what is the difference? Well, Equal Temperament uses a system of measurement called *cents* to measure small differences between note frequencies. One cent equals 1/100 of a semitone, much like a dollar is made up of 100 cents. On a guitar, each fret is 100 cents apart; on a piano, each key is 100 cents apart. If some given note was 50 cents sharp or flat, it would be exactly

halfway between two "proper" notes, equally out of tune with both of them. A smaller difference means a closer, more accurate match. The formula for comparing two frequencies n and p looks like this:

$$\text{cents} = \log (n/p) \times 3986.3137$$

Therefore Earth's transposed orbital frequency of 272.19425418 Hz compared to Equal Temperament's frequency for C# of 277.18 Hz is:

$$\log (272.19/277.18) \times 3986.3137 = -31.45 \text{ cents}$$

So… *planet Earth's orbit sings a tone which is 31.45 cents lower than a C-sharp, 33 octaves lower than middle C-sharp.*

Answer #2 (spin):

Using the same approach as shown above, *the spinning of planet Earth on its own axis produces a tone equivalent to G, 25 octaves down, 11.38 cents flat.*

The Next Obvious Question: *"Every planet sings two notes, just like Earth does. So, what are all of these notes?"*

Answer #1 (orbits):

PLANETARY ORBIT NOTES			
planet	note class	octaves below middle C	deviation (cents) from Equal Temperament
Mercury	C#	31	+33.18
Venus	A	33	+9.64
Earth	C#	33	-31.45
Mars	D	34	-25.04
Jupiter	F#	37	-13.32
Saturn	D	38	+11.96
Uranus	G#	40	-2.40
Neptune	G#	41	+31.21
Pluto	C#	41	+25.81

Answer #2 (spins):

PLANETARY SPIN NOTES			
planet	note class	octaves below middle C	deviation (cents) from Equal Temperament*
Sun	B	30	+11.26
Mercury	G#	31	+35.02
Venus	G#	33	-26.03
Earth	G	25	-11.38
Mars	F#	25	+39.53
Jupiter	A#	24	+12.56
Saturn	A	24	-10.48
Uranus	C#	24	-43.28
Neptune	D	24	-26.00
Pluto	B	28	-26.30

The Next Important Question: *"What musical intervals do the planets sing in relation to each other?"*

Answer:

The answer to this question lies in comparing ratios. Musical intervals such as octaves, thirds, and fifths, can be defined by the ratio of the two frequencies which are being compared. For example, if one note is exactly double the frequency of another note, they are said to be exactly an octave apart.

There are a few common methods of establishing these ratios, and these are called Temperaments.

Just Temperament is the preference for ratios of small integers, such as 3:2 or 4:3. Just Temperament is somehow the most pleasing to a listener's brain. There are a few variations on this approach, and there is some relevance to the Overtone Series, which is a mathematical phenomenon of Nature; I've listed some of the most commonly accepted ratios on the following page.

Pythagorean Temperament is produced by the re-iteration of the ratio of 3:2 - that is, $(3/2)^n$ **,** where n=1 through 12. This generates the 12 notes of the Chromatic Scale, but with a strange idiosyncrasy: the octave is not perfect. The 3:2 ratio, also known as the Perfect Fifth, is considered by many to be an essential element in the construction of the universe, along with other mathematical phenomena such as Phi (the Golden Mean).

Equal Temperament is the division of the perfect octave into 12 exactly-equal division, where each division is higher than the previous by a factor of $2^{1/12}$. This system is the most commonly used today, and was established as a sort of compromise to allow a musical instrument to play equally in tune in all keys. It is, however, a compromise because the resulting ratios are not as pleasing to the ear as Just Temperament.

The following table shows the ratios associated with these three different systems.

MUSICAL INTERVAL RATIOS				
Interval	Just Temperament		Pythagorean Temperament	Equal Temperament
Unison	1:1	= 1.0000	1.0000	1.0000
Minor 2nd	16:15	= 1.0666	1.0679	1.0595
Major 2nd	9:8	= 1.1250	1.1250	1.1225
Minor 3rd	6:5	= 1.2000	1.2014	1.1892
Major 3rd	5:4	= 1.2500	1.2656	1.2599
Perfect 4th	4:3	= 1.3333	1.3515	1.3384
Tritone	11:8	= 1.3750	1.4238	1.4142
Perfect 5th	3:2	= 1.5000	1.5000	1.4983
Minor 6th	8:5	= 1.6000	1.6018	1.5874
Major 6th	5:3	= 1.6667	1.6875	1.6818
Minor 7th	7:4	= 1.7500	1.8020	1.7818
Major 7th	15:8	= 1.8750	1.8984	1.8877
Octave	2:1	= 2.0000	2.0273	2.0000

The following table shows the ratios (in decimal form) of the planets' orbits. These have been transposed to a 1-octave range for convenient comparison to the Musical Interval Ratios from the preceding table.

PLANETARY ORBIT SPEED RATIOS (normalized to a 1-octave range)

planet →		Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
↓	orbit speed → (compared to Earth) ↓	4.1521	1.6255	1.0000	0.5317	0.08430	0.03395	0.01190	0.006068	0.004038
Mercury	4.1521	1.0000								
Venus	1.6255	1.2772 (+1 oct)	1.0000							
Earth	1.0000	1.0380 (+2 oct)	1.6255	1.0000						
Mars	0.5317	1.9523 (+2 oct)	1.5827 (+1 oct)	1.8808	1.0000					
Jupiter	0.08430	1.5391 (+5 oct)	1.2051 (+4 oct)	1.4827 (+3 oct)	1.5767 (+2 oct)	1.0000				
Saturn	0.03395	1.9110 (+6 oct)	1.4963 (+5 oct)	1.8410 (+4 oct)	1.9577 (+3 oct)	1.2417 (+1 oct)	1.0000			
Uranus	0.01190	1.3626 (+8 oct)	1.0669 (+7 oct)	1.3126 (+6 oct)	1.3958 (+5 oct)	1.7706 (+2 oct)	1.4260 (+1 oct)	1.0000		
Neptune	0.006068	1.3364 (+9 oct)	1.0464 (+8 oct)	1.2874 (+7 oct)	1.3690 (+6 oct)	1.7365 (+3 oct)	1.3986 (+2 oct)	1.9615	1.0000	
Pluto	0.004038	1.0043 (+10 oct)	1.5727 (+8 oct)	1.9350 (+7 oct)	1.0288 (+7 oct)	1.3050 (+4 oct)	1.0510 (+3 oct)	1.4741 (+1 oct)	1.5030	1.0000

By comparing the Orbit Speed Ratios with the Musical Interval Ratios , the orbital harmony of the planets can be ascertained. For example, Pluto and Neptune orbit in a ratio of 1.5030; this is very close to the perfect fifth's ratio of 3:2. Therefore, Neptune harmonizes a fifth higher (faster) than Pluto. Mars and Venus also orbit at an interval of a fifth (+ 1 octave). Uranus and Neptune are fairly close to a perfect octave apart. Pluto seems to be almost exactly 10 octaves lower than Mercury, although one sort of has to wonder if their extremely distant relation tells us that this is more of a coincidence. (Or… is there any such thing as coincidence?) I wonder what astrology says about all of this.

The following table shows the ratios (in decimal form) of the planets' rotation speeds. These have been transposed to a 1-octave range for convenient comparison to the Musical Interval Ratios.

PLANETARY SPIN SPEED RATIOS (normalized to a 1-octave range)

planet →	spin speed → (compared to Earth)	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
		0.03989	0.01700	0.004104	1.0000	0.9720	2.4114	2.2461	1.3884	1.4857	0.1561
Sun	0.03989	1.0000			1.5668 (+4 oct)	1.5230 (+4 oct)	1.8892 (+5 oct)	1.7596 (+5 oct)	1.0877 (+5 oct)	1.1639 (+5 oct)	1.9571 (+1 oct)
Mercury	0.01700	1.1730 (+1 oct)	1.0000		1.8379 (+5 oct)	1.7864 (+5 oct)	1.1080 (+7 oct)	1.0320 (+7 oct)	1.2758 (+6 oct)	1.3652 (+6 oct)	1.1478 (+3 oct)
Venus	0.004104	1.2151 (+3 oct)	1.0359 (+2 oct)	1.0000	1.9038 (+7 oct)	1.8506 (+7 oct)	1.1478 (+9 oct)	1.0690 (+9 oct)	1.3216 (+8 oct)	1.4142 (+8 oct)	1.1890 (+5 oct)
Earth	1.0000				1.0000		1.2057 (+1 oct)	1.1230 (+1 oct)	1.3884	1.4857	
Mars	0.9720				1.0288	1.0000	1.2405 (+1 oct)	1.1554 (+1 oct)	1.4283	1.5284	
Jupiter	2.4114						1.0000				
Saturn	2.2461						1.0737	1.0000			
Uranus	1.3884						1.7369	1.6178	1.0000	1.0701	
Neptune	1.4857						1.6232	1.5118		1.0000	
Pluto	0.1561				1.6012 (+2 oct)	1.5564 (+2 oct)	1.9306 (+3 oct)	1.7982 (+3 oct)	1.1115 (+3 oct)	1.1894 (+3 oct)	1.0000

FUTURE ENHANCEMENTS

I hope to eventually enhance the Music Of The Spheres synthesizer in the following ways:

- Save and Load presets, with descriptions displayed on screen
- apply panning to Spins tones, emulating orbital movement
- Solo and Mute buttons for each planet
- include all known moons in the Solar System, asteroid belts and Saturn's rings
- text box entry method for transposition
- gradient audibility indicators instead of only red or grey
- display frequency of each spin and orbit in Hz and indication of corresponding notes from the chromatic scale
- VSTi implementation (MIDI)
- user-selectable "pretty" (ie. Just Temperament or Equal Temperament) tones or "pure" tones (ie. non-tempered)
- account for the Sun's rotation at the poles as well as the equator (and the gas planets such as Jupiter)

BUGS / KNOWN ISSUES

The Music Of The Spheres program should operate smoothly under most circumstances. Here are a few known exceptions:

1) If you've enabled Full Screen mode, using Alt+F4 to exit may produce an error while closing.

2) If there are too many other programs running, they may interfere with the smoothness of the program's operation. For example, printing a document in the background may cause a jitter in the sound. Music Of The Spheres uses a total of 19 oscillators (sound generators), which can be a big demand for some computers.

Please feel free to email bug reports, wish lists or other comments to *twistedmusictheory@gmail.com.*

Thank you for using Music Of The Spheres ver 1.2. Happy exploring!