

De Harmonia Mundi

Of the Harmony of the World · the periods of the wandering stars, set out as intervals

1. CONTRA MUSICAM SPHAERARUM

Against the music of the spheres, as commonly told

The ancients say the spheres sing and we do not hear it because we have heard it from birth. I answer: sound is made in air by percussion, and between the moon and us there is no continuous air of that kind — else the sun would deafen us as a bell deafens the ringer. What travels from the heavens is light, and light is silent.

Coniectura: yet I do not throw the doctrine away, only its ears. Let us say instead that the heavens are not heard but counted, and that the same ratios which the ear names sweet the sky keeps in its returns. Then the music of the spheres is true as a diagram and false as a noise — which is the condition of most beautiful ideas.

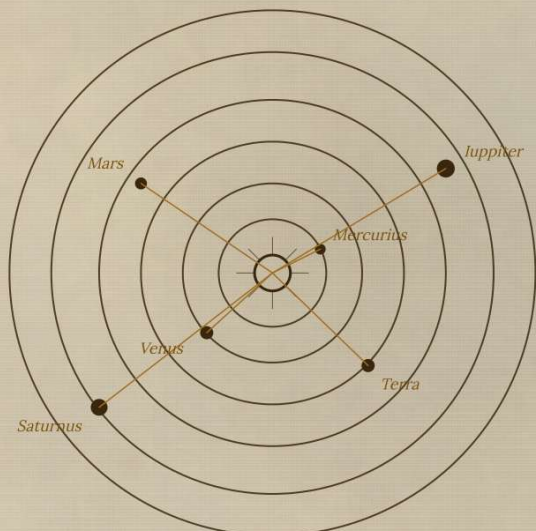


Fig. 1. The seven heavens. The radii are drawn to the fourth root of the period, that the eye may hold them all upon one leaf; the true distances are in the table opposite.

2. DE UMBRA TERRAE

Of the earth's shadow, and the timing of an eclipse

The shadow of the earth is a cone, and the moon passing through it is darkened for a time which may be counted upon the plumb. I have counted three such nights. The ratio of the darkening to the whole passage gives the breadth of the shadow where the moon crosses it, and thence the moon's distance in earth-breadths, without leaving the roof.

NOX	INGRESSUS	MORA	RATIO
Anno 1491, Nov.	62 min	98 min	1.58
Anno 1496, Mar.	58	94	1.62
Anno 1504, Iun.	64	101	1.58
Medium <i>mean</i>	61.3	97.7	1.59

The mean ratio is 1.59, which is within a hair of the golden mean and within two hairs of the minor sixth, 8 : 5. *Coniectura: I do not believe the shadow of the earth was tuned to a sixth for my benefit. I record it because a man who only records what he can explain will leave a very short book, and because three nights are too few to argue from.*

3. DE MAGNITUDE CAELI

Of the size of the heavens, reckoned from the shadow

From the breadth of the shadow where the moon crosses it, and from the moon's apparent width of half a degree, the distance follows: the moon stands some thirty earth-breadths off, and is a quarter of the earth in width. The sun must be far greater and much further, for the shadow it casts converges, and a cone converges only toward a light broader than the body that blocks it.

CORPUS	DISTANTIA	LATITUDO
Luna	30 terrae	0.27
Sol <i>by the cone</i>	>1200	>10
Sol <i>true</i>	11700	109

My reckoning gives the sun above twelve hundred earth-breadths and I have written «at least», for the instrument is my thumb and the night was cold. *Coniectura: the true figure is larger than I dare write. If the sun is a hundred earths wide then the earth is a pebble beside a millstone, and the millstone stands still while the pebble turns — which I have already said on this leaf in four words and will not say again in forty.*

4. TABULA CAELESTIS

The periods of the wanderers reduced to intervals of the ear

STELLA	ANNUS	RATIO	INTERVALLUM
Mercurius	0.241	1.00	the ground
Venus	0.615	2.55	octave + third
Terra	1.000	4.15	2 octaves
Mars	1.881	7.80	3 octaves –
Iuppiter	11.86	49.2	5 octaves +
Saturnus	29.46	122.2	7 octaves –

Ratio is each period divided by that of Mercury. Observe that Venus stands to the Earth almost as 8 to 5, and Jupiter to Saturn almost as 2 to 5: the sky is full of near-consonances and empty of exact ones. *Coniectura: nature tunes as a good player tunes — close enough that the chord stands, never so close that it dies of exactness.*

5. DE LUMINE CINEREO

Of the ashen light — why the dark moon is not wholly dark

The old moon is faintly seen within the arms of the new. The cause is the sun's light returned from our seas: the earth shines upon the moon as the moon shines upon us, and the ocean is the mirror. Thus the two bodies pass light between them as two strings pass a tone.

$i/d^2 \cdot s/d$
<i>light falls off as the square of the distance; sound as the distance simply — coniectura</i>

Coniectura: I say light thins by the square because it spreads upon a surface, and I suspect sound does likewise, though the ear reports otherwise — the ear being a poor witness in matters of quantity and an excellent one in matters of kind.

The sun does not move; the earth turns beneath it and carries us as a boat carries a sleeping man. Write it small, and in the mirror hand.

6. CHORDA CAELESTIS

The celestial monochord — a string laid against the sky

Let a canon of seven courses be built, each course tuned to a planet's period by the table above, and let a wheel turn them in the ratio of their years. Then a man may hear in one minute what the sky takes thirty years to perform. I have reckoned the gearing; I have not built it, for the wheel of Saturn wants one hundred and twenty-two teeth to Mercury's one, and no smith in Milan will cut it.

CHORDA	LONGITUDO	DENTES	VOX
Mercurius	1200 mm	1	the ground
Venus	471	3	e" near
Terra	289	4	c'''
Mars	154	8	g'''
Iuppiter	24	49	beyond hearing
Saturnus	10	122	silence

Observe that the outer planets fall off the instrument altogether: their courses would be shorter than the width of a finger and could not be stopped. *Coniectura: the sky is playable only in its middle register. Whether this is a fact about the heavens or about strings, I cannot decide, and the question keeps me from sleep more than it deserves.*

7. DE SILENTIO

Of silence, and why the argument matters

If the spheres do not sound, why keep the doctrine at all? Because a ratio that governs two strings and also two orbits is telling us something about ratios, not about strings; and a man who finds the same rule in the sky, in the gut, in the pipe and in the body has not found four rules but one, and may hope one day to write it.

The ancients heard music in the heavens because music was the only mathematics they could feel in the body. We should not laugh at them; we should keep their diagram and throw away their ears. *Coniectura: I begin to suspect that number is not a description we lay upon the world but the joint at which the world is put together, and that the ear was given to us as a second eye, to see that joint in the one place where it moves — in time. If this is true then music is not an ornament of philosophy. It is philosophy's only window onto duration, and I have wasted twenty years painting.*

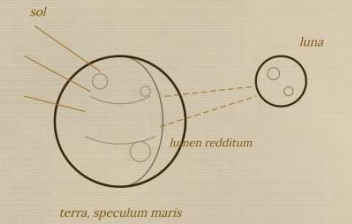


Fig. 2. The earthshine: sunlight struck from our oceans onto the shadowed face of the moon.

AD MARGINEM

In the margin, twice underlined

יוצאם יז נסח סלז II

The sun does not move. Four words only, in a hand smaller than the rest, as a man writes what he does not wish to argue about yet.

NUMERI CAELI

Near-consonances of the pairs

PAIR	TRUE	NEAR
Venus : Terra	1.625	8:5
Terra : Mars	1.881	15:8
Mars : Iuppiter	6.306	19:3
Iuppiter : Saturnus	2.484	5:2
Mercurius : Venus	2.552	5:2

Jupiter and Saturn come within a hundredth of the fifth above the octave; Mercury and Venus follow them within the same hair. *Two pairs of the six keep the same interval. I cannot say whether this is the hand of the maker or the hand of the man who chose which six to write down.*

NOCTURNA OBSERVATA

Nights of watching, and the note assigned

NOX	STELLA	VOX
iii Mar.	Saturnus	ground
vii Mar.	Iuppiter	fourth
xi Apr.	Mars	fifth
xv Apr.	Sol	octave
ii Mai.	Venus	tenth
ix Mai.	Mercurius	twelfth

Six clear nights from the roof of the Corte Vecchia, the periods taken from the tables and the notes set by their ratios, not by my liking of them.

CONTRA PTOLOMAEUM

Three objections to the music of the spheres

- i If the spheres sound, why is the sound not heard? Because it never ceases, they say — but the ear is dulled by *change*, not by constancy.
- ii A sound requires air, and there is no air above the moon. Then the harmony is a harmony of number only, and the word music is borrowed.
- iii The periods make no clean ratio. Ptolemy mends them by choice. *Coniectura: what must be mended by choice was never measured.*

I set these down not to destroy the doctrine but to keep it honest. A number that will not come out is worth more than a number persuaded.

ERRATA ASTRONOMICA

Where the tables and my own eye disagree

STELLA	TABULA	VISUM
Saturnus	29 y 5 m	29 y 6 m
Iuppiter	11 y 10 m	11 y 11 m
Mars	1 y 10 m	1 y 10 m
Venus	224 d	225 d

«The heavens keep proportion but make no sound; ours is the only sphere that sings.»