Music and the curvature of space

by Jonathan Tennenbaum

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The basic arguments in favor of a tuning at $C = 256$ (equivalent to A no higher than 432 Hz) were outlined at the Schiller Institute conference in Milan, Italy on April 9, 1988, and are available in published form. I want to take advantage of this circumstance to present some more recent work on the scientific basis of $C = 256$ tuning, and to call attention to some of the important physical questions related to the problem of scientific tuning.

Most musicians and many physicists imagine that the basic scientific principles of acoustics—the generation, propagation and hearing of sound—had been established in all essentials by the last half of the 19th century, at the time of Helmholtz. This is not true. Firstly, there are many specific points upon which we know that Helmholtz's acoustical theories are fundamentally wrong, points of great importance for musical practice. Secondly, quite apart from such specifics, we know that the physical basis of music cannot be addressed adequately without considering the *curvature of physical space-time,* a problem which we are really only beginning to come to grips with today.

You may be interested to know that the marvelous and very peculiar phenomenon of "cold fusion" raises the same issue of the curvature of space-time. In fact, it is not too much to say that the problem of "cold fusion" is very closely related to the scientific bases of $C = 256$ tuning in music!

The mind as causal in the universe

Let me first address the essence of the matter in fundamental terms.

Human knowledge concerning our universe divides itself generally into three domains. First, we have the domain of knowledge of what we call "inorganic" processes: the properties of electrons, atoms and molecules, light and gravity, and so forth.

Second, we have the domain of knowledge of living processes, which includes medicine, biology, ecology, and so forth.

And third, we have the domain of knowledge of the mental processes of human mind, and especially of those creative processes of thought which absolutely distinguish Man from the beasts. Music of course is a central feature of this third and highest domain.

Now, if we examine the relationship of these three domains, the essential thing to realize is that *they all concern one and the same universe.*

Thus, we *think* with this remarkable organ called the brain, which is a living process. Besides being living, the brain is also a physical process involving electrons, atoms, molecules, and electromagnetic radiation, organized in a special way. So, if you rightly reject "Cartesian dualism"—which is actually a form of paranoid schizophrenia—then you are obliged to consider the efficient, lawful connection which must exist between the three domains.

Not only is the human mind a physical process, but human thought processes have immediate, concrete effects upon the rest of the universe. In fact, as human society grows, as science and technology advances, the human mind becomes an ever more powerful *causal factor* in the physical universe. Indeed, the existence of the human mind is the single most important "experimental fact" in all of physics.

Now, the professional physicist will tell you that there are certain basic parameters which underly *every* process which occurs in the universe, no matter what it is. These include such things as the speed of light c, the Planck quantum of action h, the charge of the electron e, the so-called fine structure constant α, and so forth. If any of these basic parameters were to change, then *everything* would change. For example, the propagation of sound involves interactions between air molecules which are complex quantum electromagnetic configurations, and thus involves all the fundamental parameters of physics.

However, this is a clumsy and somewhat misleading way to state it. In reality, the so-called fundamental parameters only reflect the fact that physical space-time has a certain *curvature*—an overall geometry—such that every process in the universe is shaped accordingly. The study of this question in mathematical physics goes back to Nicolaus of Cusa, and to the 19th-century work of Gauss, Riemann and the Italian geometer Eugenio Beltrami, and has most recently been revived by Lyndon LaRouche and his scientific friends.

Of course, we do not see this curvature directly (that is the proper business of science to discover!); but by way of a metaphor, think of drawing forms on the surface of a sphere: You can draw any form you want, but as long as it is drawn on the spherical surface, the form will be curved in a certain

way, independent of its particular shape. It "inherits" the curvature of the sphere upon which it is drawn. The curvature of the universe is different from the static kind of curvature a sphere possesses, however, because the universe's curvature embraces space and time together. It shapes all *processes*, from those of human mind down through the domain of living organisms and the inorganic domain from astrophysics into the microscopic, subatomic level.

Since the creative powers of the human mind, as realized in scientific and technological progress, embody most directly the causal principle of the universe, it is the lawful characteristics of creative mentation which most clearly demonstrate the curvature of physical space-time.

An exciting implication is, that something congruent to creative mentation must pervade the whole universe, including the inorganic domain. This is called "negentropy."

Musical tuning is not arbitrary

Now this very sketchy discussion of curvature of physical space-time provides us with a most advantageous vantage-point for examining the problem of musical tuning. The fact that space-time is curved in a specific way imposes an absolute measure on all existences. We are not allowed to arbitrarily stretch the universe as if it were made of chewing-gum!

Since music must embody and perfect the creative powers of the mind, while at the same time being organized as a physical process involving tones and propagation of sound, we must examine all three of the above-mentioned domains to adduce proof for tuning at C = 256. It is only those invariant features which persist throughout the three domains which can claim to cohere with the curvature of physical space-time.

This kind of unified approach is nothing new in and of itself. It is explicitly formulated, for example, in Plato's *Timaeus,* in St. Augustine's *De musica*, and later in the *World Harmony* of Johannes Kepler. It was also at the basis of the musical system of the High Sanskrit culture of India. The question of "tuning" implies how to organize human activity in accordance with the law—and we say now, space-time curvature—of the universe.

So, for example, Sanskrit culture considers the construction of the astronomically-based calender, the proper measurement of time, certain aspects of medicine as well as the setting of proper vowel sounds and rhythms for the recitation of poetry, and the tuning of instruments, *all as a single problem*. The classical Indian astronomical treatise of Aryabhata, written around 500 A.D., defines the smaller units of time as *syllables and breaths* (*pranas*), and relates these units to the astronomical cycles of the year, the month and the day, as follows:

1 breath (*prana*) corresponds to 10 long syllables
1 *vinadika* = 6 breaths

1 *nadi* = 60 *vinadikas*
1 day = 60 *nadis*
1 month = 30 days
1 year = 12 months

If we calculate backwards, we find that the ancient Indian prana was 4 seconds in our time-scale. If we divide the Indian *prana* in half, ten successive times, we come to the period of oscillation corresponding to C = 256. In other words, the frequency associated with breathing would be a "C" ten octaves lower than C = 256.

The time unit of the "second" upon which the Western system of time measurement is based, also derives from the astronomical cycles, and in particular by dividing the day (rotation of the Earth), first into 24 hours, each hour into 60 minutes, and each minute into 60 seconds. The period of oscillation for C = 256 is derived from a second by eight successive divisions by 2, i.e., 8 octaves above the basic "C" which is given by the famous "seconds pendulum"—a pendulum completing one complete oscillation in one second.

The numbers used in both the Western and Indian systems of division of time are all derived from the "geometrical numbers" 2, 3, 4, and 5, which arise from the triangular, square, and pentagonal faces of the regular solids. The latter, in turn, express the geometrical characteristics of visual space, and thus, indirectly, the curvature of physical space-time. It is the same geometrical numbers which Kepler used to define the consonant intervals of music.

Some historical background

Let me add a few historical remarks on the how C = 256 was originally identified as the "scientific tuning."

The first explicit reference to the tuning of middle C at 256 oscillations per second was made, as far as I know, by a contemporary of J.S. Bach. It was at that time that exact technical methods developed making it possible to determine the exact pitch of a given note in cycles per second. The first person said to have accomplished this was Joseph Sauveur (1653-1716), called the father of musical acoustics. He measured the pitchs of organ pipes and vibrating strings, and defined the "ut" (nowadays known as "do") of the musical scale at 256 cycles per second. J.S. Bach, as is well known, was an expert in organ construction and master of acoustics, and was in constant contact with instrument builders, scientists, and musicians all over Europe. So we can safely assume that he was familiar with Sauveur's work. In the time of Beethoven the leading acoustician was Ernst Chladni (1756-1827), whose textbook on the theory of music explicitly defined C = 256 as the scientific tuning.

As we have noted in various publications, it is the coincidence of this astronomically defined value of the "C" octave series with a register shift of the bel canto soprano voice where it should be—namely between F and F-sharp in that tuning—which is the main basis for regarding C = 256 as the ·

scientific tuning. The belcanto register shift is defined not by mere physiological requirements of the voice, but also by the criterion of *beauty* which derives from the creative faculties of the human mind.

Evidence from the domain of physics

But we can find further confirmation of C = 256 in the other domains of human knowledge referred to above.

Firstly, I should note that psychologists have long identified the frequency of 16 cycles per second (4 octaves above

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the "seconds pendulum," and 4 octaves below C = 256) as a very important psychophysiological threshold, called the "flicker frequency." It is at this frequency that the mind begins to integrate a series of repeated stimuli (such as flashes of light or sound pulses) into a continuous "Gestalt." Most likely this "flicker frequency" is related to the characteristic frequency ranges of the brain waves (alpha: 8 Hz and higher, theta: 4-8 Hz).

Secondly, my colleague Warren Hamerman has completed a study of the "tuning" of living cells. In the field of optical biophysics we discover that living tissue emits and absorbs electromagnetic radiation at a series of specific frequencies or wavelengths. As Mr. Hamerman has shown, the most important of these frequencies can be arranged in an ordering very similar to the musical scale, but 42 octaves higher!

Perhaps the most important single frequency is that associated with the main absorption band of DNA, the key substance in all living processes. This band corresponds to wavelengths of between 263 and 269 nanometers (a nanometer is one-billionth of a meter). The center frequency of this band (corresponding to 265 nm) is

$$1.1283 \times 10^{15} \text{ cycles per second}$$

which is exactly 42 octaves above the frequency 256.54 cycles per second! Thus, the key biological molecule is tuned very precisely to C = 256!

A further, most striking additional piece of evidence comes

from nuclear physics. Already Leibniz in the 17th century insisted that there is no such thing as passive, inert matter, but that all matter is merely a phenomenon associated with *action*. Much later, in the 1920s, Louis DeBroglie and other physicists completed the demonstration that the particles of matter such as electrons, protons, neutrons, and atomic nuclei are all associated with very high frequency oscillations. In other words, we could say that these entities are constantly being maintained by processes "tuned" to particular frequencies. Now, the DeBroglie frequency for the proton is

$$2.26876 \times 10^{23} \text{ Hz}$$

which corresponds nearly exactly to the "G" in the 69th octave above middle C = 256 Hz. (The difference between the proton's "G" and the G defined by equal tempering in C = 256 is less than the 28th part of a semitone.) The frequency of the neutron is very slightly higher, by the 40th part of a semitone. This means that the DeBroglie frequencies of the nuclei of the chemical elements are all very nearly integral multiples of the proton frequency (and the frequency of the hydrogen atom), which is tuned to G in the C = 256 tuning.

The other crucial "elementary particle," the electron, corresponds nearly exactly to the "A" in the 58th octave above middle C (differing by less than the 10th part of a semitone from the equal-tempered value). In fact, the French physicist Joel Sternheimer has shown that the masses of the so-called elementary particles are organized closely in accordance with the musical scale. This holds, however, only in the tuning C = 256, not in A = 440. (The nominal difference between these two tunings is somewhat less than half a semitone, far bigger than either the differences between the DNA, proton, and electron frequencies and the equal-tempered values, or the differences between equal-tempered and the Keplerian scale values. The actual discrepancy between the A = 440 and C = 256 tunings, on the proper nonlinear metric as opposed to the nominal arithmetic one, is qualitatively larger; in demonstrations of the two tunings this difference is commonly heard as an entire semitone.)

Lest this appear to someone as "numerology," let us emphasize the following: Such basic parameters as the fundamental frequency of DNA and the DeBroglie frequencies of the proton, neutron, and electron on the one hand, and the astronomical cycles on the other, all reflect the curvature of physical space-time. Furthermore, if we examine the physics of generation and propagation of the bel canto musical tone, we find that 1) the singer as a living organism is "tuned" in accordance with the DNA in all of his or her cells, and 2) the DeBroglie frequencies are embedded everywhere in the singer and in the air through which sound propagates, as a central feature of the way in which physical action is organized through electrons, protons, and neutrons which constitute singularities of matter. To escape C = 256, we would literally have to banish ourselves from the universe!