The Monochord in Ancient Greek Harmonic Science by David Creese

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The image of Pythagoras at the monochord has become iconic for the beginnings of music theory in terms of the quantification of pitch-relations. The fact that it is in all probability entirely unhistorical has been dawning upon specialists for quite a while. It is to be hoped that David Creese's thoroughgoing study will be received widely enough as to eradicate lastingly the misleading conceptions both of an archaic monochord as a scientific instrument and of a primarily Pythagorean origin of pitch-studies.

But this is by no means Creese's only conclusion and probably not even one of his major concerns. Rather, while tracking the extant evidence related to the tool called monochord or κανών over the centuries, he is interested in the ways in which the material instrument, as well as its more immaterial echoes in writers' minds, interact with arithmetical, geometrical, musical, and physical conceptions in different periods and different authors to produce various flavors of harmonic or 'canonic' science.

The chronological examination is preceded by an important chapter on ancient scientific method, which outlines similarities as well as differences between the κανών and scientific instruments such as the armillary sphere, and shows that the use of the monochord must be understood in the context of mathematical diagrams (and later also in relation to tables). The relation of its origins to a type of arithmetical proposition illustrated by quasi-geometrical diagrams in which lines represent numbers was decisive for the development of its use; although it would have been perfectly straightforward to divide the tone into two equal semitones geometrically,[1] such a truly

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[1] Here a reference to Busch 1998, 115–117 would have been in order.

geometrical approach was simply never envisaged and the monochord continued to hover (somewhat uncomfortably in my view) between the two mathematical disciplines as a device sporting a continuous line that merely served to illustrate ideas about integers. In a sense, the monochord's 'geometry' remained one-dimensional and I have sometimes wondered if Creese's insistence on a geometrical aspect is not in fact exaggerated, after all. In any case, Creese persuasively argues that this limitation is best understood in historical terms: the establishment of integer arithmetic as a paradigm of mathematical harmonics had predated the monochord.

Creese's historical overview starts by examining and discarding the anecdotal stories related to Pythagoras, blacksmith and all, that pop up many centuries later. Surprisingly, even to a sceptic, 'the invention of the monochord is not attributed to Pythagoras in any extant text before the third century AD [90].' This absence of evidence for its usage before much later inevitably raises the question: 'How, then, were the ratios of the concords discovered?' Apart from the traditional art of tuning panpipes, Creese makes a case to associate this discovery with Hippasus' metal disks, whose pitch would have been proportional to their thickness (while it is inversely proportional to string or pipe lengths). This characteristic would account better for early pitch theories, where higher pitch is associated with greater force or speed.

Creese is always extremely cautious about not taking absence of evidence for evidence of absence, but in the end he settles on the reasonable hypothesis which dates the origin of the monochord in the later fourth century BC, and argues in detail that its existence is not presupposed either in Philolaus or Archytas. When the monochord finally makes its appearance, it is in a perfectly designed (a couple of logical flaws notwithstanding) logico-mathematical argument, the *Sectio canonis*, which owes much to a tradition of public demonstrations (ἐπιδείξεις and ἀποδείξεις) that is fruitfully delineated by Creese. The *Sectio canonis* may be a reaction to Aristoxenus' apodeictic *Elements*, whence perhaps also the preoccupation of grounding its propositions on a physical basis: it contains a very advanced account of sound-transmission, which Creese interprets as inspired by a newly conceived need to integrate the behavior of strings within an acoustical theory of pitch. Although the κανών is not mentioned until the last chapters,

one might use it profitably also as a 'diagram-reading instrument' to illustrate some of the preceding propositions.

In later writers, the notion of a 'division of the monochord' becomes more problematic, as this may indicate a merely intellectual (algebraic) enterprise just as well as the real thing (involving at least one sounding string and a ruler), especially whenever big numbers which cannot literally be applied to an instrument are involved. It is unclear, though doubtful, whether this expression may also denote the mere listing of interval sizes. Eratosthenes' figures are plausibly interpreted as a practically successful (albeit mathematically problematic) representation of Aristoxenus' standard shades of the three genera. Along the way, Creese points out that Eratosthenes had developed a root-extracting device which would have made it possible, at least in principle, to construct precisely Aristoxenian sorts of intervals—and that it is very unlikely that he would have applied it to string-division.

Later sources fall within the Roman period, when harmonics had become a subject in the schools and was produced in handbooks in which Aristoxenian and mathematical positions are juxtaposed with different degrees of confusion or mutual integration. In this era, different approaches are typically understood in terms of the roles they attribute respectively to reason and perception, a criterion extensively discussed by Ptolemaïs. Significantly, the term 'canonics' emerges in this context, so that the monochord, after its centuries-long obscurity, finally becomes the hallmark of its discipline.

As a consequence, the sources start discussing different ways to use it as well as some possible complications. Creese elucidates the principles of practical elegance that inform the different approaches that were used to demonstrate the ratios of the concords. For instance, plucking both sides of a string minimizes the number of necessary bridge positions (Panaetius). Here the contrast between a static diagram and the sequential adjustments of the monochord's bridge becomes decisive. However, the octave plus fourth, concordant to the ear but described by a mathematically dissatisfying ratio of 8:3 remains a problem[2] until Ptolemy finally manages to integrate it inconspicuously in his system. Most importantly, in Adrastus

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[2] Adrastus, for example, lists it as a consonance but fails to demonstrate it on the κανών.

we find the first evidence of an evolving awareness of fundamental issues regarding the monochord's precision as an instrument. Creese discusses the divisions of Nicomachus' *Harm. man.* (but surprisingly not Boethius' detailed account, which is widely believed to be based on Nicomachus' lost fuller treatment), as well as the accounts of the so-called 'Timaeus Locrus' and of Thrasyllus. Here the major shortcomings of the monochord become finally evident: whenever larger structures are envisaged, the required large numbers can be transposed to a physical ruler only approximately and large ranges lead to ill-sounding small string-lengths.

The final chapter is entirely devoted to Ptolemy, who developed the κανών in regard to its technical practicalities and used it in accordance with hitherto unmatched scientific standards, directly (and largely effectively) addressing issues of precision and reliance as well as reconnecting the study of harmonics with the concert-goer's musical experience. Ptolemy perceived the need of a many-stringed experimental instrument in order to assess properly the validity of musical structures by playing melodies rather than intervals, and introduced new geometrical concepts into its construction. As an astronomer, he was familiar with the demands and the practical issues involved in the production of precise instruments and he made sure that his various new models of many-stringed 'monochords' would obtain interval measurements that satisfied unprecedented scientific standards, pushing potential technical errors beneath the threshold of perceptibility. He also introduced a common 120-units ruler with hexagesimal fractions, perhaps replacing a set of differently marked rulers that were used in former demonstrations: now the positions of notes in different divisions could be compared easily in absolute terms. Even the geometrical construction of the ἑλικών, which used the intercept theorem to construct the most important musical ratios, was made into an ingenuous practical instrument that enabled modulations of key by means of a sliding common bridge. When Ptolemy finally ventures to attach musical meaning to astronomical phenomena, the ecliptic is envisaged as a gigantic curved 'monochord', populated by planets that act as moving bridges.

Creese's lucid and sometimes humorous style makes thorny technical questions accessible—in this, his obvious ease with mathematical problems helps a lot. I have only one serious issue, regarding the fundamental dichotomy between the 'Pythagorean' and the 'Aristoxenian'

viewpoints, which I present in the following along with a number of quibbles, if only to pay due tribute to such a committed book.

Like so many writers who focus on the mathematical strand of harmonics, in my opinion Creese does not do perfect justice to Aristoxenus' alternative approach [27–30, 42–46, 163]. Although he gives an exemplarily reasoned and, in principle, accurate account of the questions involved, his conclusion that Aristoxenus talks about the same intervals as the mathematical theorists and is, therefore, ultimately wrong, is not warranted since it is based on the argument that the precise size of the perfect fifth and fourth was uncontested in antiquity.[3] The actual difference in pitch that is in question is smaller than the 100th part of a tone and the difference in consonance was, therefore, not assessable by ancient means: Creese's comparison to the practice of interval-'sweetening' mentioned by Aristoxenus is misleading, since this would have involved intervals as large as an eighth or a tenth of a tone, depending on which modern interpretation one prefers.

Consequently, it is true that Aristoxenus and the mathematical faction talk about 'precisely' the same intervals but only according to the standards of precision available to them; therefore, the Aristoxenian system is nevertheless entirely consistent. It does not involve three different kinds of semitones, albeit of barely perceptible difference (as Creese claims), because it does not start from the same mathematically defined interval sizes for the consonances. Rather it is based on an effectively 'tempered' system, as we would call it, for which Aristoxenus was in the position to prove experimentally that it consisted of incontestable consonances.[4] In doing so, Aristoxenus implicitly denied the *precise* identification of consonances with simple

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[3] This problem seems eventually to be acknowledged on page 163.

[4] Creese's description of Aristoxenus' experiment [45] implausibly assumes that he worked his way through the circle of fifths only in one direction and then compared the last pitch against the first. Such a procedure is incompatible with the epideictic structure of the argument: for practical reasons, a demonstration (in school or in public) almost certainly demanded a row of 12 strings set up in advance. Their pitches would have formed an interlocking series of 'perfect' fifths and fourths, much as on the modern piano. (It must be borne in mind that the shortcomings of modern tempered tuning are not related to fifths and fourths but to thirds, which do not bear on Aristoxenus' reasoning at all). Cf. Franklin 2005, 19–21.

ratios of whatever; the study of a physical basis for the phenomenon of consonance was alien, anyway, to his project of harmonics.[5] Therefore, when Creese says that Aristoxenus' system was 'founded on the assumption that irrational intervals exist' [163], he interprets it from outside and, thus, unfairly: the Aristoxenian paradigm holds no assumptions on the basis of which such a kind of irrationality could possibly be derived.

The monochord could not mediate between the two positions because the differences in question fall outside its scope: the measured pitch differences could never be smaller than those accessible to the hearing which establishes the measured pitches, a determination governed as well by the precision with which the hand can shift the bridges (and work the tuning pegs, in the case of Ptolemy's many-stringed versions).[6] Therefore, it is hardly possible to demolish the Aristoxenian assertion that there are six tones in an octave by means of the κανών [228]: the construction on the instrument can do no more than reproduce what has been worked out arithmetically, and this only imperfectly.[7] This fact seems misunderstood, when Creese emphasizes, following Ptolemy, that

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[5] A possible way out of the dilemma why the consonances would happen to seem to close to simple ratios if they are not identical with them is hinted at in *Harm.* 68.10–12: pure consonance might not occur at a precise interval but within a very small range. This view is also much closer to practice, since no physical manipulation of an instrument could ever realize mathematical precision, while the very notion of consonance proves that it can be achieved.

[6] An additional problem in establishing precise intervals on the monochord by ear may arise from the friction between string and bridge, which, when the latter is moved, causes the tension to adjust not smoothly but in small steps. The smaller this effect is, the poorer is the sound quality for a given bridge material.

[7] On a κανών with a free string length of about 90cm, i.e., built as large as possible so as to still play in the range of the cithara (as seems implied by Ptolemy's frequent reference to this instrument), the differences between tempered and perfect fifths and fourths translate into differences in bridge positions ranging from 0.5 mm to 1 mm, depending on the pitch of the bounding notes. When performing a corresponding true perception-based experiment, each position would thus have to be established with a precision significantly below half a millimeter in order to get halfway consistent results.

> the amount by which six tones exceed an octave is constant,
> as the carefully controlled demonstration proves: the result
> will be no different if it is repeated.... [327]

This is true, but since that demonstration merely construes on the κανών the results of calculations, as long as arithmetic does not change, the results cannot be different by definition. It is similarly true that the 'apparent aberration...cannot be explained away as observational error', but this is only because observation had never contributed to the setup of the experiment. Contrary to what Creese seems to imply, this 'experiment' highlights that, when it comes to deciding between Aristoxenus' and the canonists' viewpoints, the 'experimental' instrument cannot do anything to confirm the arithmetical prejudices on the basis of which it is set up.

And here come the quibbles. The first is that at some points I would have liked Creese to engage more closely with the Greek texts that he quotes (sometimes extensively—for which I am immensely grateful), instead of relying on existing translations. For instance, he poses the important question 'How did «κανών» come to mean 'monochord'?' [17], but I am not sure his following remarks, which focus on the ruler's straightness rather than its function as a tool of measurement, are meant as an answer. In any case, I think that in Ptolemy's explanation [Düring 1930, 5.12f] «κανονίζειν» should not be translated as 'to straighten' but as 'to measure out' [cf. 228, 260].

Similarly, I do not think that the citation of Ptolemaïs *ap.* (?) Porphyry *In Harm.*

> κανονικὸς δ' ἐστὶ καθόλου ὁ ἁρμονικὸς ὁ περὶ τοῦ ἡρμοσμένου ποι-
> ούμενος τοὺς λόγους [Düring 1932, 23.5f]

is correctly translated by

> ...who constructs ratios in connection with attunement. [77f;
> 217]

The passage abounds with forms of «λόγος» that drift between the various meanings of the word. Here, however, a mathematical meaning would be very awkward, «ποιεῖσθαι τοὺς λόγους» being such a common expression for 'talking'. The definite article and the final

position rather suggest that the definition focuses on «περὶ τοῦ ἡρμοσμένου»: so '...who talks about attunement'.[8] Otherwise, the definite article in «τοὺς λόγους» would compel us to construe the implied contrast as somebody 'who constructs the ratios in connection with something else'—not really a viable alternative. As a definition, this is, of course, weak and does not serve to distinguish the κανονικοί from other types of ἁρμονικοί. But the context shows that «καθόλου» must be understood in a strong sense, in contrast to the usual distinctions: 'In a general sense, «κανονικός» denotes the ἁρμονικός, the one who talks about attunement'. This reflects the entirely parallel «καθόλου» in [Düring 1932, 22.25–27], where «κανονική» is introduced as the 'Pythagoreans'' general term for ἁρμονική. And finally, this explains the irritating «καί» (dropped by the ms. of g) in 23.9 «εἰσὶ δὲ καὶ ἑκάτεροι τῷ γένει μουσικοί» ('and *similarly*, both are generically μουσικοί').

Also, I suspect Creese misunderstands Ptolemaïs' evaluation of the Aristoxenian μουσικοί [231: on Düring 1932, 24.5–6]: 'She...regards it as unsurprising that they cannot make intelligent use of the κανών'. As I understand it, Ptolemaïs rather regards it as natural that these people mistrust the monochord:

> κατὰ δὴ τούτους εἰκότως οὐ πανταχῆ αἱ λογικαὶ ὑποθέσεις τοῦ κανόνος σύμφωνοι ταῖς αἰσθήσεσιν

> According to these people, to be sure, it is only to be expected that the rational postulates of the κανών are not always concordant with the perceptions. [Barker 1989, 241]

Nicomachus, *Harm. man.* [von Jan 1895, 254.19–21], «διὰ πασῶν εὑρήσει τὸν ἀπὸ τῆς ἡμισείας πρὸς τὸν ἀπὸ τῆς ὅλης ψόφον μείζονα», cannot mean 'you will find that the sound from the half string stands at an octave to the larger sound from the whole' [262, 274], but '...that the sound from the half string is an octave larger than the one from the whole'. This is also demanded by the context, where Nicomachus explains that pitches are inversely related to strings: the higher sound is the 'larger' one.

In Ptolemy, *Harm.* at Düring 1930, 17.20–26 [306f], I find it misleading to translate the participles with present tenses and to

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[8] The supposed meaning would call for something like «ὁ ἐν λόγοις σκοπῶν τὸ ἡρμοσμένον».

take them as starting a new sentence ('It [i.e., the string on the κανών] does not acquire its pitch in a random way...'). These do not characterize the monochord in general but specify the conditions (i.e. Ptolemy's innovations) under which it will perform the outlined task: so, '...since it will not acquire its pitch in a random way...'.

Related, finally, is also a slight infelicity on page 259, where a discussion of the algebraic abacus follows a Greek text mentioning the *abacus* (ἄβαξ) in the sense of the geometer's drawing-board.

So much for the translations. Here are some more questions concerning which I should also like to take up in discussion with the author.

Although it is true that Adrastus claims that notes whose pitches stand in no rational proportion are not properly called notes (φθόγγοι) but sounds (ἦχοι) [5], I do not think this view can necessarily be projected to 'the earliest stage of musical thinking in the mathematical tradition' [23]. The claim is either rather sophisticated in allowing the existence of 'notes' only in harmonic relation to each other, i.e., only if more than one is present in the context of a single performance (which Aristoxenus' definition would not necessarily entail [Da Rios 1954, 20.16–19]) or very silly in that it effectively confuses notes and intervals, which would be just typical for Adrastus' arguments.

Although Creese assumes that the monochord was introduced in the later fourth century, he is always at pains to point out that the evidence for its absence earlier is only negative. But, at the least, we might obtain some positive evidence for the monochord's recent introduction from the beginning of *Sect. can.* prop. 19, where the full vibrating length of the string is equated with the βόμβυξ ('entire pipe'), thus introducing the division of strings in relation to the boring of finger-holes in woodwinds [cf. Hagel 2005, 60; 2009a, 333n21]. This is conceivable only if pipes had been the model instrument for similar demonstrations until shortly before.

With regard to Hippasus' disks, Creese states that 'the behavior of pitched sound becomes visibly and directly (not inversely) analogous to the behavior of numbers' [95]. But this presumes a modern view in which higher pitch is conceived of as, well, 'higher', just as higher numbers are 'higher'. The related spatial concept, at least,

evolves only in later antiquity.[9] In original Greek thought, high pitch
is ὀξύς (sharp), and low pitch βαρύς (heavy) [see 297n29]. From this
point of view, the disk experiment runs contrary to expectation: the
'heavier' sound is produced from the lighter disk. Similarly, the mater-
ial aspects of 'sharp' include especially thin objects such as blades and
points [cf. Düring 1930, 7.25–27], while 'sharp' sounds arise from the
thicker, blunter disks. Note that even a late author such as Ptolemy
[Düring 1930, 8.3–5] may pair the terms, viz. «ἐλάττων τε καὶ ὀξύτε-
ρος (ψόφος)» ('smaller and higher-pitched (sound)') [cf. 297]. From
an archaeo-technical viewpoint too, the thickness of bronze disks
is not a very plausible starting point—would there have been tools
for reliably measuring, let alone producing, two disks with a given
ratio of thickness?[10] Tuning disks, I presume, involved grinding them
down until they rang in the desired harmony. Afterwards, one might
have gauged whether the resulting measurements were in accord with
known numeric relations rather than detecting these. So, I think that
much of the argument for disks breaks down and that pipes may have
been a more plausible candidate; note too that lutes had always been
lingering at the peripheries, even though Greek iconography remains
long silent about such instruments.

Repeatedly, Creese argues that a physical theory of sound in
terms of speed or force is 'difficult, if not impossible, to illustrate...with
chordophones of any sort' [120]. But pitch is often perceived as τάσις
(tension), a concept familiar to a nation of lyre players, where higher
pitch is directly connected with exerting greater force in tuning. The
cultural awareness of the likeness of bow and lyre string, expressed not
only in the figure of Apollo but also in the terms «νεῦρον»/«νευρά»
applicable to both, and famously in *Od.* 21.406–411, nicely illustrates
how a string of greater tension supplies greater force and speed. All
this makes the fact that Archytas [Diels and Kranz 1951, 47 A1] does
not mention strings all the more remarkable.

Creese gives a short account of how Archytas may have derived
his enharmonic interval ratios from a hypothetical procedure for tun-
ing a lyre [128n149]. There is very little evidence for enharmonic lyres.
But even granted their existence, I just do not see why anybody in

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[9] See Rocconi 2002: note Nicomachus' idea (quoted below) that 'larger' sounds
are higher sounds.

[10] Cf. the technically well-informed remarks at Düring 1930, 17.16–20.

his right mind would tune them 'starting with the upper tetrachord tuned to Archytas' diatonic and the lower tetrachord tuned to the "ditonic" diatonic' (and this by a process which still involves non-concordant adjustments), instead of simply tuning the desired scale.

Creese accepts the unity of the entire document known as the *Sectio canonis*, mainly because of the fact that its title states a project that is not fulfilled until its last chapters [133f; 171]. But even if the title is original (all we know is that it was current in Porphyry's time, almost 600 years later), the original project is plausibly concluded with chapter 19, covering the 'fixed notes' [cf. Hagel 2009b, 247f.]. Notably, its final sentence proudly states 'Thus all notes of the non-modulating scale will have been found on the κανών' ('emended' to 'fixed notes' by modern editors). Chapter 20, which I regard as a later addition, has nothing of that kind.

The term «διαύλων» printed from Plutarch, *Non posse* 1096a–b and translated as 'double-auloi' in the passage [139] is Einarson and Lacy's implausible solution to a textual problem (mss. «δι' αὐλῶν»): it denotes the race course, never that double-pipe called the *aulos*.

I am not sure whether Aristoxenus really 'disallowed the exception of *Posterior Analytics* 1.7' [154], which enabled harmonics to make use of mathematics even though they are different sciences. Aristoxenus still employs arithmetic to add and subtract intervals; he only severs the 'Pythagorean' tie to physics, entirely in line with Aristotle's concept. As a consequence, it is doubtful whether the *Sectio* can be viewed as the more Aristotelian rival project to Aristoxenus' *Elementa* [156].

Creese takes pains to explain why Plato adopted the ditonic diatonic of all possible systems and tends to view the *Sectio* as dependent on his tradition [162]. But since both Philolaus before and the *Sectio* after Plato have the same system, which derives directly from the tuning of heptatonic chordophones,[11] it is Archytas who is the odd one out and Plato's 'choice' demands little explanation [see Franklin 2002].

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[11] Cf. the historically doubtless related Near Eastern system, although without ratio mathematics, and the probably independent contemporary Chinese scales.

With his usual salubrious caution, Creese does not assume that the monochord stands behind [Aristotle] *Phys. prob.* 19.12, where by division of the string 'two *nētai* (*e'*) are produced in the *hypátē* (*e*)' [169]. As Creese remarks, the production of harmonics on the lyre is a possible option here. However, the claim that there are *two* of the higher notes would either rest on a remarkable observation of the string's second vibration mode or on an extrapolation from another instrument. The lute, on the other hand, is an unlikely basis, since the higher part of the string is never plucked. On a fretted lute, producing *two* notes at the octave is, anyway, plainly impossible. On a lute without frets, the precise pressing point for the octave is not in the centre of the string; and if the resulting notes are made equal by pressing the middle point, these are sharper than the octave, both because of the length of string occupied by the finger and because the act of pressing increases the tension. All known theories of woodwind pitch presuppose that the sound 'exits' through the first open finger hole, which also precludes the notion of *two* high notes.

Creese wrestles with the question why Eratosthenes kept the traditional ratios of the ditonic diatonic (i.e., what is often called the 'Pythagorean' tuning) instead of producing something closer to Aristoxenus' standard diatonic, and even considers that these ratios are compiled from a different work [208]. However, Aristoxenus is unmistakable that this variant of diatonic results from tuning by consonance—which inevitably yields the ditonic diatonic when described in terms of ratios.

Regarding Adrastus, a crucial question concerns which portion of Theon of Smyrna's text one attributes to him. However, I do not think that one can excise Hiller 1878, 69.12–70.19 but still keep the sequel [254 with n121],[12] since 71.3 refers directly back to 70.16f: note the unusual «ἀεί».

It is agreed that Adrastus' problematizing the spatial extension of a bridge is mistakenly applied to the bisection of the tone; and Creese rightly points out that, if taken seriously, it would tear down the entire edifice of canonic science [256]. However, Creese's restatement of Adrastus' argument in correct terms is practically relevant only if

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[12] In this respect, Creese is following Barker [1989, 223n59f], who considers as a possible solution that Theon is summarizing a thought which he did not fully understand.

one uses the parts of the string on both sides of the bridge (which Adrastus does not do): otherwise, nothing would prompt us to place the *center* of the bridge at the desired point instead of its *edge*, which, at least theoretically, makes the lengths directly comparable (the real problem is one of tension, which Creese addresses later on).

In the Greek text of Nicomachus, *Harm.* [von Jan 1895, 260.12–17], the usual comma is printed before «ἕως τοῦ ἑπτακαιεικοσιπλασίου» [263], apparently indicating that the parenthesis about Plato is understood as closed: '...but in the way of Timaeus of Locri (whom Plato also followed): right up to the twenty-seven-fold ratio'. But Creese understands the last part as belonging to the description of what Plato did [267f]. This strikes me as unlikely. Anyway, such a reading would be possible only if following Timaeus 'right up to the twenty-seven-fold ratio' is the point in question (and not a mere side-thought, as which it would make sense only in a limiting meaning, as if Plato could have followed Timaeus *beyond this expanse*, which is of course nonsense). Thus, the nature of the alleged shortcomings of Eratosthenes and Thrasyllus is settled by the text: they did not use the (musically absurd) cosmic 'Pythagorean' range for their divisions of the κανών.

Finally, I think that Creese's criticism of Ptolemy's reasoning regarding a string's distortion by the bridge [313f] is partially flawed: it does not seem to me that the string is 'stretched...also...by an amount equal to the arc' where the string touches the bridge. This arc, which Creese regards as added in some way to the total length, merely reflects (and compensates) the respective arcs on the end-bridges which the string now no longer touches (in Creese's Fig. 6.2, ΘM = HK + ON). So the distortion is fully accounted for by the effect of pushing the string upwards, which, as Creese rightly notes, increases the tension.

All this is not to detract from the fact that David Creese has filled an important gap in the studies of ancient Greek music in a masterful way, in a book that enriches the libraries of everybody interested in this particular field of study, philologist or music historian, as well as in the development of scientific thought in general.

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