
La Musa dimenticata

Aspetti dell'esperienza
musicale greca
in età ellenistica



EDIZIONI
DELLA
NORMALE

21



SEMINARI E
CONVEGNI

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La Musa dimenticata

Aspetti dell'esperienza
musicale greca
in età ellenistica

a cura di
Maria Chiara Martinelli

con la collaborazione di
Francesco Pelosi e Carlo Pernigotti



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*Per ricordare
Roberto Pretagostini
e Luigi Enrico Rossi*

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Presentazione

Alcuni anni fa è stata avviata, alla Scuola Normale di Pisa, un'attività di studio e di ricerca sull'esperienza musicale della Grecia antica fondata sulla consapevolezza, ormai ampiamente condivisa, che per accostarsi alla comprensione di un fenomeno così importante nella vita e nel pensiero dei Greci sia necessaria la cooperazione di varie competenze. Alle ricerche individuali (relative a temi quali la *performance* e la trasmissione dei testi musicali, la riflessione platonica sulla musica e le teorie sulla percezione del suono) si è affiancato un costante confronto fra i membri del gruppo e un proficuo scambio con altri studiosi. È allora nata l'idea di un momento di riflessione e discussione comune, e si è scelto di focalizzare l'attenzione su di un'età precisa della 'storia musicale' dei Greci, il periodo ellenistico. Epoca di decadenza, secondo la storiografia antica sull'argomento, e quindi rimasta generalmente in ombra nelle sintesi moderne, l'Ellenismo ci è parso meritevole di una riconsiderazione condotta alla luce della sempre più ricca documentazione in nostro possesso (dai documenti letterari e figurativi a quelli papiracei ed epigrafici) e della varietà di metodologie che oggi possono essere messe a frutto.

Nelle giornate del convegno, che si è svolto nel settembre 2006, sono stati considerati vari aspetti dell'esperienza musicale ellenistica: i contesti della fruizione, lo statuto sociale dei musicisti, la prassi esecutiva, la riflessione teorica e filosofica, la produzione e conservazione dei testi musicati. Sono state giornate assai intense per la qualità delle relazioni e della discussione che ne è sorta; a noi piace ricordarle anche per il clima di amichevole confronto e collaborazione che si è venuto a creare

Siamo lieti, ora, di dare alle stampe i contributi che vengono da questa esperienza. Il lettore troverà inizialmente alcuni lavori che ricostruiscono, a partire dalle parole di poeti e di storici e dalle testimonianze papiracee ed epigrafiche, i contesti della pratica e della fruizione musicale, lo *status* sociale dei professionisti della musica, l'organizzazione degli spettacoli. Segue un'ampia parte dedicata alla

riflessione sulla musica, sia nei suoi aspetti squisitamente filosofici, sia in quelli che riguardano la teoria e la sua storia. Anche nella successiva sezione, dedicata all'organologia, si affiancano prospettive di vario genere: da proposte ricostruttive basate sulle considerazioni degli antichi teorici e sui documenti in nostro possesso (resti di strumenti ma anche di testi musicali), a indagini iconografiche e storiche che si interrogano sulla diffusione e sul ruolo sociale e 'ideologico' degli strumenti. Si arriva infine a parlare dei documenti della scrittura musicale: fra questi abbiamo il piacere di pubblicare qui per la prima volta un papiro posseduto dalla Biblioteca Vaticana. Anche questi reperti aprono diverse prospettive di ricerca, fra le quali sembra particolarmente interessante quella di interrogare i documenti a proposito dell'ambiente in cui furono impiegati e delle finalità per cui furono apprestati.

Nel concludere il nostro lavoro, vogliamo ringraziare i relatori (anche quelli che non hanno potuto inviarci un testo scritto) e tutti coloro che hanno arricchito il convegno della loro presenza e del loro contributo alla discussione, in particolare Felice Costabile, Glenn Most, Egert Pöhlmann. Abbiamo il piacere di estendere il ringraziamento a Luigi Beschi e Christoph Stroux, che si sono in seguito uniti con preziosi interventi in forma scritta.

Nella revisione del volume ci siamo avvalsi dell'aiuto di giovani studiosi, che pure vogliamo qui ringraziare: *in primis* Guido D'Alessandro, poi Luigia Businarolo, Emilio Capettini, Marta Cardin, Leyla Ozbek, Ivanoe Privitera, Luca Ruggeri. Molte grazie anche a Bruna Parra per la sua paziente assistenza redazionale.

E infine grazie alla Scuola Normale, per aver offerto, in questi anni, sostegno alle nostre ricerche e, in particolare, alla realizzazione del convegno e di questi atti.

Dedichiamo questo volume, con affetto e rimpianto, alla memoria di due grandi maestri e carissimi amici: Roberto Pretagostini, scomparso poco dopo il convegno, Luigi Enrico Rossi, venuto a mancare quando questo volume era già stato dato alle stampe. Entrambi avevano arricchito il nostro convegno con la passione, la sensibilità e l'acume di sempre, Chico guidando sapientemente la discussione finale, Roberto aprendo i lavori con un contributo, che possiamo qui pubblicare, grazie alla disponibilità di sua moglie Silvana, proprio nella forma in cui lo ricordiamo dalla sua voce.

MARIA CHIARA MARTINELLI, FRANCESCO PELOSI, CARLO PERNIGOTTI

Avvertenze e abbreviazioni

Ove non diversamente segnalato, i seguenti scritti di interesse musicologico sono citati secondo le edizioni qui di sotto elencate, indicando, di norma, i numeri di pagina e i rigli delle medesime (fanno eccezione gli *Elementa rhythmica* di Aristosseno, citati per capitoli, e il *De musica* di Filodemo, citato secondo il numero della colonna).

Aristide Quintiliano (ARISTID. QUINT., *De mus.*)

Aristidis Quintiliani De musica libri tres, edidit R.P. Winnington-Ingram, Lipsiae, Teubner 1963

Aristosseno (ARISTOX., *El. harm.*; *El. rhythm.*)

Aristoxeni Elementa harmonica, R. Da Rios recensuit, Romae, Typis Publicae Officinae Polygraphicae 1954

ARISTOXENUS, *Elementa rhythmica. The Fragment of Book II and the Additional Evidence for Aristoxenean Rhythmic Theory*, ed. with introduction, translation and commentary by L. Pearson, Oxford, Clarendon Press 1990

Bacchio (BACCH., *Harm.*)

Bacchi Gerontis Isagoge, in *Musici Scriptores Graeci*, recognovit prooemiis et indice instruxit C. Janus, Lipsiae, Teubner 1895, 283-316

Claudio Tolomeo (PTOL., *Harm.*)

Die Harmonielehre des Klaudios Ptolemaios, hrsg. von I. Düring, Göteborg, Elanders Boktryckeri Aktiebolag 1930 (Göteborgs Högskolas Årsskrift, 36.1)

Cleonide (CLEONID., *Harm.*)

Cleonidis Isagoge harmonica, in *Musici Scriptores Graeci*, recognovit prooemiis et indice instruxit C. Janus, Lipsiae, Teubner 1895, 167-207

Filodemo (PHILOD., *Mus.*)

PHILODÈME DE GADARA, *Sur la musique, livre IV*, texte établi, traduit et annoté par D. Delattre, 2 tomes, Paris, Les Belles Lettres 2007

Gaudenzio (GAUD., *Harm.*)

Gaudenti philosophi Harmonica introductio, in *Musici Scriptores Graeci*, recognovit prooemiis et indice instruxit C. Janus, Lipsiae, Teubner 1895, 317-356

Nicomaco (NICOM., *Ench.; Exc.*)

Nicomachi Enchiridion, in *Musici Scriptores Graeci*, recognovit prooemiis et indice instruxit C. Janus, Lipsiae, Teubner 1895, 209-265

Excerpta ex Nicomacho, *ibid.*, 266-282

Porfirio (PORPH., *In Harm.*)

Porphyrios Kommentar zur Harmonielehre des Ptolemaios, hrsg. von I. Düring, Göteborg, Elanders Boktryckeri Aktiebolag 1932 (Göteborgs Högskolas Årsskrift, 38.2)

Pseudo-Euclide (PS.-EUCLID., *Sect. Can.*)

Euclidis Sectio canonis in *Musici Scriptores Graeci*, recognovit prooemiis et indice instruxit C. Janus, Lipsiae, Teubner 1895, 113-166

Teone di Smirne (THEON SM.)

Theonis Smyrnaei philosophi platonici Expositio rerum mathematicarum ad legendum Platonem utilium, recensuit E. Hiller, Lipsiae, Teubner 1878

I documenti musicali antichi sono citati secondo:

DAGM = *Documents of Ancient Greek Music. The Extant Melodies and Fragments*, edited and transcribed with commentary by E. Pöhlmann and M.L. West, Oxford, Clarendon Press 2001.

Per le edizioni dei papiri si fa riferimento alla *Checklist of Editions of Greek, Latin, Demotic, and Coptic Papyri, Ostraca and Tablets*, ed. by J.D. Sosin, R.S. Bagnall, J. Cowey, M. Depauw, T.G. Wilfong, and K.A. Worp, in <<http://scriptorium.lib.duke.edu/papyrus/texts/clist.html>>.

Le abbreviazioni relative ai testi epigrafici sono in generale quelle usate nel *Supplementum Epigraphicum Graecum*.

Le abbreviazioni delle riviste sono quelle dell'*Année Philologique*.

Altre abbreviazioni:

Anec. Bekk. = *Immanuelis Bekkeri Anecdota Graeca*, I, Berolini, Nauck 1814, II-III, Berolini, Reimer 1816-1821

ARV² = J.D. Beazley, *Attic Red-Figure Vase-Painters*, 3 vols., Oxford, Clarendon Press 1963²

CA = *Collectanea Alexandrina. Reliquiae minores Poetarum Graecorum Aetatis Ptolemaicae 323-146 a.C. Epicorum, Elegiacorum, Lyricorum, Ethicorum*. Cum epimetris et indice nominum edidit I.U. Powell, Oxonii, Clarendon Press 1925

Dox. = *Doxographi Graeci*, collegit recensuit prolegomenis indicibusque instruxit H. Diels, Berolini, Reimer 1879

FGrHist = *Die Fragmente der griechischen Historiker*, von F. Jacoby, Berlin, Weidmann/Leiden, Brill 1923-1958

GDK = *Die griechischen Dichterfragmente der römischen Kaiserzeit*, gesammelt und hrsg. von E. Heitsch, 2 Bd., Göttingen, Vandenhoeck & Ruprecht, 1963²-1964

GL = *Grammatici Latini*, ex recensione H. Keilii et al., 7 voll. et suppl., Lipsiae, Teubner 1855-1880

GMAW² = E.G. TURNER, *Greek Manuscripts of the Ancient World*, Second Edition revised and enlarged, ed. by P.J. Parsons, London 1987 («BICS», Suppl. 46)

Index Bonitz = H. BONITZ, *Index Aristotelicus*, Berolini, Reimer 1870

LGPN = *A Lexicon of Greek Personal Names*, ed. by P.M. Fraser, E. Matthews, M.J. Osborne, S.B. Byrne, Oxford, Clarendon Press, 1987-

LIMC = *Lexicon Iconographicum Mythologiae Classicae*, 9 Bd., Zürich-München, Artemis Verlag 1981-1999

LSJ = *A Greek-English Lexicon*, compiled by H.G. Liddell and R. Scott, revised and augmented throughout by Sir H.S. Jones, Oxford, Clarendon Press 1940⁹; *Revised Supplement*, ed. by P.G.W. Glare, Oxford, Clarendon Press 1996

PCG = *Poetae Comici Graeci*, ediderunt R. Kassel et C. Austin, Berolini et Novi Eboraci, de Gruyter 1983-

PG = *Patrologiae cursus completus. Series Graeca*, accurante J.P. Migne, Paris, Migne 1857-1866

PMG = *Poetae Melici Graeci*, edidit D.L. Page, Oxford, Clarendon Press 1962

RE = *Paulys Realencyclopädie der classischen Altertumswissenschaft*, neue Bearbeitung begonnen von G. Wissowa fortgeführt von W. Kroll, K. Mittelhaus u.a., Stuttgart, Metzler/Druckermüller 1893-1997

SOD = *Demetrius of Phalerum. Text, Translation and Discussion*, ed. by W.W.

Fortenbaugh and E. Schütrumpf, New Brunswick and London, Transaction Publishers 2000 (Rutgers University Studies in Classical Humanities, 9)

SVF = *Stoicorum Veterum Fragmenta*, 3 voll., collegit H. von Arnim; IV, quo indices continentur, conscripsit M. Adler, Lipsiae, Teubner 1903-1924

TrGF = *Tragicorum Graecorum Fragmenta*, 5 voll., ediderunt B. Snell, R. Kannicht, S. Radt, Göttingen, Vandenhoeck & Ruprecht, 1971- 2004

Nella grafia dei nomi greci non è stato imposto uno *standard*, ma sono state rispettate le scelte dei singoli autori.

Reconstructing the Hellenistic Professional *Aulos*

There can be little doubt that some of the compositions that have come down to us from the Hellenistic era, in more or less fragmentary state, were meant to be accompanied by the *aulos*¹. The most obvious instance is the so-called First Delphic Paeon (DAGM 20), whose text expressly refers to the «shimmering melodies» of the instrument as forming part of the paeon's performance. If its technical implications are considered, however, one is struck by the contrast between the extended musical scale that the piece exploits and the limitations imposed by the characteristics of the *aulos*: on each of its pipes, the five fingers of one hand can cover only a restricted span, and no more than five holes at most at any given moment. So it is by no means clear whether the instrument would have been able to follow the melodic line of the song – which was normally the only part of vocal music committed to writing. The question of largely unison as opposed to entirely heterophonic accompaniment is of course highly important for our general picture of ancient music and has consequently been the subject of sometimes heated debate. Apart from some well-known texts², the archaeological remains of instruments of the *aulos* family make it clear that the two pipes did not play in unison anyway; but if neither of them doubled the vocal melody, one would have to admit considerably more complexity in ancient music than is often presumed. The following argument approaches the problem from the organological side: a reconstruction of some of the main features of one typical Hellenistic professional *aulos* type will be proposed, whose tonal capabilities can then be related to the musical fragments.

It is well known that Hellenistic professional *auloi* employed at least two kinds of key-work, which gave the player access to a far greater

¹ On the *aulos* in general, cf. HOWARD 1893; WEST 1992, 81-107; for its history, also BARKER 2002.

² Cf. BARKER 1995; on the *aulos* especially, HAGEL 2004.

number of holes than the five or six of more primitive types. A major breakthrough in this direction is generally attributed to the late fifth century Theban aulete Pronomus, who is reported as having been the first to play in the three principal modes without having to switch instruments³. This was not merely a technical innovation. Prerequisite to the construction of a polymodal *aulos* is the conceptualisation of its musical structure, i.e. the establishment of definite relations between the individual modes regarding their pitches and intervals. Very probably, at this point the transformation of the old modes into the ‘keys’ of later theory (*tonoi*, *tropoi*) started⁴. The all-encompassing system of *tonoi* as we know it from ancient treatises was devised, in its general features, by Aristoxenus more than a century later; but in his work an account of two more primitive schemes is preserved⁵. In our context, one of them is of special interest: according to Aristoxenus, it was conceived «with view to *aulos* boring» (πρὸς τὴν τῶν αὐλῶν τρύπησιν βλέποντες). Aristoxenus’ scathing criticism on his predecessors’ shortcomings has given rise to a picture of half-dull mere-theorists who did not know better than to model their tonal system on the finger hole distances of the old *aulos*, producing something entirely useless in practice. This is however not what the phrase itself appears to say. The deverbal τρύπησις suggests the procedure of laying out the finger holes rather than its eventual result, the τρυπήματα⁶. This opens the possibility that those theorists were not using the *aulos* as a model, but to the contrary devising a model scheme for the *aulos*. As we have seen, precisely this sort of enterprise must have been pursued in the late fifth century, leading to the system of *tonoi* played on Pronomus’ *aulos*. A priori, it is very likely that Aristoxenus refers exactly to this *aulos*-based tradition – once it existed, it is hardly likely that anybody would have felt the need for an alternative, impractical, scheme. We

³ PAUS., IX, 12, 5; ATH., XIV, 631e (for Pronomus’ unquestioned primacy in the art, cf. AP, XVI, 28). An *aulos* modulating between Dorian, Phrygian and Lydian is presupposed for the dithyrambs of Philoxenus, Timotheus, and Telestes in DION. HAL., *Comp.*, 19. PLAT., *Resp.*, 399d, mentions *aulos* music as the leading factor in the development of tonal variety.

⁴ Another, string-based, systematization of the three modes may underlie the triple-cithara of Pythagoras of Zacynthus, who is probably to be dated earlier in the fifth century: ATH., XIV, 637c-f; cf. ARISTOX., *El. harm.*, 46, 10-11.

⁵ ARISTOX., *El. harm.*, 47, 1-13.

⁶ Used in the sense of «finger holes» in ARISTOX., *El. harm.*, 52, 9 f.; 53, 10.

will see presently how the particulars of the pre-Aristoxenian system support our assumption.

Before doing so, we must return to the technical aspects for a moment. Much of ancient *aulos* mechanics is known to us from finds ranging over several centuries and a vast geographical area: within a surprisingly short time, key-work-equipped *auloi* were heard everywhere from the Southern Nile valley to the Oxus and the British islands⁷. In principle, there were two kinds of mechanism, called ‘sleeves’ and ‘sliders’ respectively. The latter are small plates that travelled up and down the tube in order to uncover and cover their ‘finger’ hole. They were operated by slender rods, which could reach a considerable length, terminating in knobs. The space where these could usefully be positioned was however limited, so that only few of them could be mounted on each pipe. Such sliders are useful only for holes not accessible to the fingers in any playing position: those holes, that is, which are located far down the tube and yield the lowest notes⁸. Holes which might possibly be fingered must be equipped with ‘sleeves’ instead: thin seamless metal bands with holes that open and close the finger holes below them by revolving around the tube. They are operated by the fingertips with the help of small knobs.

The relation of bores, hole positions and pitches is subject to well-known laws of physics. The pitch of any playable note depends mainly on the effective length of the reed plus that of the tube, approximately down to the first open finger hole; to a lesser degree on the diameter of the main bore; the temperature of the air inside it also plays a role. On the other hand, the absolute pitch of surviving melodies can be gauged by the capabilities of the male voice: it is commonly accepted that ancient notation can be related to a kind of pitch standard, with

⁷ Finds are described in: HOWARD 1893, 7-8; BODLEY 1946; MASARAKI 1974; WEST 1992, 87-88; LAWSON, WARDLE 1998; LITVINSKY 1999; BYRNE 2000; cf. also the fragments in DEONNA 1938, 325, B 124-7637, pl. 812; FLOURENTZOS 1991, 44-45, pl. 4.1-2.

⁸ Sliders are also conceivable for the *syrinx*, which was almost certainly a speaker hole high up the tube opened for the production of harmonics (HOWARD 1893, 30-35); that it was controlled by sliders may be suggested by the use of *κατασπᾶν* and *ἀνασπᾶν* in this context (ps.-ARIST., *De aud.*, 804a; ARISTOX., *El. harm.*, 27, 1; PLUT., *Non posse suaviter vivi*, 1096b), but apparently up to now no archaeological evidence for this type is known.

an uncertainty of hardly more than a tone⁹. Another constant are the physical capabilities of the human hand, which cannot span a range of finger holes larger than about 12-14 cm, depending also on the specific spacing of the holes within. From all this follows that one pipe in one typical playing position can hardly cover a melodic range of more than about a sixth; at higher pitches, however, the possible range increases, while it is significantly reduced at lower pitches.

To this the fact may be added that with any given technique of manufacture, metal sleeves require some minimum breadth to ensure the demanded degree of air-tightness, depending on the smoothness of the surface and the friction that is tolerated for collar operation. The tolerable leakage is mainly dependent on the stiffness of the reed – the stiffer the reed is, the tighter must the tube be – and the length of the resonating air column below the closed hole; for low notes the total leakage from all higher holes closed by their bands must be taken into consideration¹⁰. Currently we lack the archaeo-technical expertise to ascertain the critical parameters. If they became significant at all, they would have suggested a comparatively low range for mechanical *auloi*, as compared to their simple ancestors, in which melodic capabilities tended to rise with the instruments' pitch.

Now we can return to the pre-Aristoxenian system of *tonoi* that probably originated in the context of early mechanical *auloi*. According to Aristoxenus, its six scales were arranged at the following intervals, given in fractions of tones: Hypophrygian – $\frac{3}{4}$ – Hypodorian – $\frac{3}{4}$ – Dorian – 1 – Phrygian – $\frac{3}{4}$ – Lydian – $\frac{3}{4}$ – Mixolydian. As I have shown earlier¹¹, this at first sight curious structure reveals its inherent rationale in the light of the famous ancient scales that are transmitted in the work of Aristides Quintilianus¹². Once the functionally similar notes of these, e.g. their *mesai* or their disjunctions, are arranged in the

⁹ Cf. WEST 1992, 273-276. This is not to say that this standard could not have varied somewhat in different times and regions; but the extant musical documents, dating within a range of half a millennium, indicate no shift.

¹⁰ Since slider holes are few and located at the lower end of the pipe, their respective allowance for leakage must be significantly larger than that for sleeve-covered holes. This enabled their light construction, which did not take advantage of the constant pressure guaranteed by a ring around the tube at, or at both sides of, its hole.

¹¹ HAGEL 2000, 168-181.

¹² ARISTID. QUINT., *De Mus.*, 18-20. Their source is perhaps a lost work of Aristoxenus, rather than a commentary on Plato's *Republic* (BARKER 1982, 183-184;

intervals mentioned, it emerges that their highest notes are perfectly aligned. This is shown in Figure 1; note that Aristides' list provides corresponding scales for only four out of the six *tonoi*; about the structure of the two 'Hypo' modes we can only speculate.

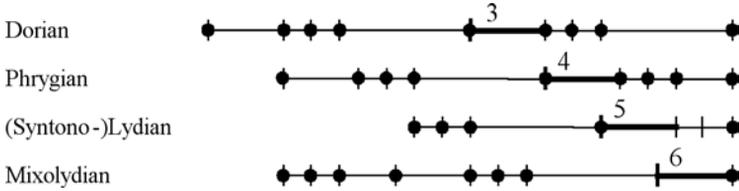


Fig. 1: The *aulos*-based pre-Aristoxenian system of *tonoi*

The alignment of the highest notes is not borne out of mere theoretical aesthetics. If the various scales are understood as variant configurations on a polymodal *aulos*, their common upper limit is an almost necessary consequence of instrumental design. Like their simpler relatives, mechanical *auloi* had only one thumb hole, located second from the top. The reason is obvious: only at the upper end was the relation of fingers to holes unequivocal. In playing positions further down the pipe, i.e. when some of the highest holes were obturated by means of their sleeves, each hole could be accessed by different fingers, according to the demands of the melodic context; consequently all had to be bored at the upper side, which precluded the involvement of the thumb in melodic playing. It entails that in most playing positions only four holes could be fingered at a time without altering the configuration of available holes by means of the rotating sleeves – which is always a complicated and time-consuming manipulation, when compared with simple fingering. Only the highest position, where the players availed themselves of the thumbhole also, gave immediate access to six primary notes (i.e., notes played from open holes, without applying additional techniques such as half-stopping). Accordingly, any practical design incorporating several scales must have aimed at including the thumb hole in all of them, as far as possible, which is tantamount to aligning their upper ends as closely as

BARKER 1989, 419 note 112). For their connection to the theory of octave species, cf. MOUNTFORD 1920, 25-28; WINNINGTON-INGRAM 1936, 21-30; WEST 1992, 227-228.

possible. Thus the early system of *tonoi* opens an unprecedented view into a period when important progress in music theory was instigated by very practical questions, quite unlike the detached abstraction that almost every page of Aristoxenus' *Harmonics* radiates.

Pronomus' polymodal *aulos* is probably to be distinguished from the later modulating *aulos*. The integration of several scales within one instrument gave access to novel possibilities of modulation, which in turn inspired a new generation of instruments. Modulation, as in modern Western music, was conceived as governed by the circle of fifths; as a consequence, extensive modulation led to a grid of twelve semitones within the octave. It was left to Aristoxenus to complete the theoretical formulation of this framework; but in practice rows of semitones must have become crucial earlier. Within a tonal space of five contiguous keys – as for instance from Lydian to Dorian in the standard arrangement, already pre-Aristoxenian – and the diatonic genus only, no less than nine consecutive semitones are required; in the chromatic genus, most highly esteemed by the composers of the time in question, modulation between only three adjacent keys would have generated the complete set of semitones. If we maintain the upper limit of the earlier *aulos*, the relations of Figure 2 emerge (which is still based on Aristides' ancient scales with their quartertones)¹³: Dorian, Phrygian, and Lydian now appear in their canonical distance of two consecutive tones.

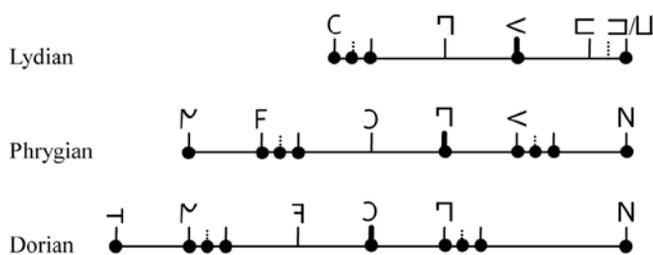


Fig. 2: The *tonoi* of the modulating *aulos*

¹³ It is virtually certain that quartertones were always obtained by half-stopping holes, since individual finger-holes would lie too close together (a pair of two smaller holes to be covered by a single fingertip, as on some modern recorders, was apparently never used, while cross-fingering has little effect on instruments with a large ratio of finger hole to main bore diameter).

At this stage we can supply the notes with the appropriate ancient signs (Figure 2 gives the instrumental variant; I shall deal with the earlier stages of the ancient notation on another occasion). We find that our reconstruction predicts that the highest pitches of one important type of professional *aulos* were associated with the notes Γ Ν in Phrygian and Dorian, with Ε Λ in chromatic and diatonic Lydian, and with Δ □ in enharmonic Lydian, respectively¹⁴. Such a prediction is precisely what we need in order to test the present hypothesis against the evidence of Hellenistic music.

We start from the following assumption: if an instrument type such as postulated existed in Hellenistic times, and played as important a role in the development of the theory as we have ascribed to it, it is to be expected that its specific tonal capabilities left their imprint on the music of its time. If there was any relation between the vocal line and the pitches playable on the accompanying instrument, one should be able to detect these traces in vocal scores also, if only by means of statistics. In addition, we must hope that the general features of our modulating *aulos* were not abandoned rather soon, since our early musical documents postdate its hypothetical evolution by anything from one to two-and-a-half centuries. To be sure, the absence of evidence would not disprove our theory, because both a limited validity of the latter two assumptions and the contribution of non-auletic compositions to our sample might render the sought influences unobservable.

Since we have dealt with the theoretical instrument's upper limit only, we must compare this limit with those of the extant melodies from the Hellenistic era. Due to the nature of the evidence the chronological boundary can be drawn neatly, as there is a gap in the evidence comprising roughly the two centuries around the turn of the era. For a valid statistical test, we also need a sample with which to compare the data: otherwise the fact that the predicted limit turns out to be consistent with the evidence might mean no more than that it is, by coincidence, close to the vocal limit. For this purpose, the ancient melodies from the Roman imperial era suggest themselves: they make use of the same notation, and there is no a priori reason why they should implement different boundaries, if not because of a

¹⁴ For the present purpose, we must of course set minor variations of intonation, as defined by the Aristoxenian theory of shades (*khroai*) aside, in favour of the pre-Aristoxenian 'standard definitions' of the three genera (*genē*) by means of tones, semitones and quartertones (on the history of the genera, cf. HAGEL 2008).

different instrumental background. Here again, any test would fail if the proposed Hellenistic *aulos* had continued to exert an unbroken influence in late antiquity.

	$\Gamma N / E \sqcup$	other
BC	6	8
AD	8	41

$p = 0.0453$
(Fisher's exact test)

	$\leq \Gamma N / E \sqcup$	other
BC	10	4
AD	19	30

$p = 0.0312$

Fig. 3: Top notes in musical documents BC

The evidence is gathered in Figure 3. In the left table, the extant melodies are divided into those whose upper limit is exactly the predicted pitch, in either of its forms (enharmonic $\Delta \sqsupset$ is not considered, both because enharmonic notation would not be distinguishable from chromatic, and because the enharmonic had already gone out of fashion in the later fourth century)¹⁵. In the right table, pieces that go beyond that limit are set against those which do not violate it (i.e., including those which do not even reach it). It becomes apparent that in the Hellenistic era, 71% of the extant pieces do not exceed the inferred auletic top note, while this is true for only 39% of the later compositions. Similarly, in the Roman Imperial period, only a random set of 16% go up to precisely the note in question, but a fully 43% of the earlier melodies. In spite of the small sample size, the differences are significant at a level below 5%. Thus the statistics clearly indicates that the pitch of $\Gamma N / E \sqcup$ plays the role of a typical upper limit in Hellenistic times, but loses it later on. Since our reconstruction of the auletic *tonoi* systems predicted the former part of this statement, its validity is effectively corroborated by the musical fragments: the highest note of a typical Hellenistic professional *aulos* is $\Gamma N / E \sqcup / \Delta \sqsupset$, a minor sixth above $C C$.

From the pitch of this note – about 270 Hz \pm a semitone, according to the accepted theory – and from the span of the human hand, we

¹⁵ The only plausibly enharmonic piece is the *Orestes* papyrus (DAGM 3), with highest vocal note Δ , but probably a higher, although isolated, instrumental L . Consequently it is here counted as an instance against the tested hypothesis.

can assess the extent of that highest playing range, which featured so prominently in *aulos* practice and early scalar theory: the uncertainties in the parameters are so small that they can hardly affect the result, which is expressed in the comparatively large units of semitones. A finger span of about 11.5 cm brings us to a hole six semitones below, which can be fingered with ease; the next lower semitone is available only with considerable difficulty, and only if the ring finger plays the hole an entire tone higher. In other words, the lowest fingered hole lies either a semitone or a tone above CC . This also accords with the demands of the heptatonic scales of ancient music theory, in which a grid of six or seven semitones can be filled with five scalar steps at most, here associated with the five fingers of one hand¹⁶.

These are the fingered notes of the main playing position. Below these, the next open hole will give an additional lowest note, whose pitch is not in any way determined by the capabilities of the hand. For most continuous melodic scales, it lies a tone or a semitone below the lowest fingered note, in chromatic scales perhaps one and a half tone also. Consequently, its typical representatives are expected to be CC and $\text{Y}\underline{\text{L}}$, eight and nine semitones below the top note, respectively; under special circumstances $\text{P}\cup / \text{Π}\mathcal{D}$ also comes into question: in short, the expected typical lowest note within the main playing position is $\text{CC} \pm$ a semitone. In Figure 4, the details of this reconstruction are juxtaposed to a bar graph indicating the relative frequency of extant notes from the Hellenistic period.

¹⁶ Maximal realizations, including the bounding notes are, for six semitones: diatonic $\frac{1}{2} - 1 - 1 - \frac{1}{2}$ (Hypolydian $\text{O}\underline{\text{Z}}\text{I}\text{Z}\text{E}$); chromatic $\frac{1}{2} - \frac{1}{2} - 1\frac{1}{2} - \frac{1}{2}$ (Hypolydian $\text{O}\underline{\text{Z}}\text{N}\text{Z}\text{E}$), $\frac{1}{2} - 1\frac{1}{2} - \frac{1}{2} - \frac{1}{2}$ (Hypoaolian $\text{O}\text{N}\text{H}\text{Z}\Delta$); enharmonic $\frac{1}{4} - \frac{1}{4} - 2 - \frac{1}{4} - \frac{1}{4}$ (Hypolydian $\text{O}\underline{\text{Z}}\text{N}\text{Z}\text{E}\Delta$); for seven semitones: diatonic $1 - 1 - 1 - \frac{1}{2}$ (Lydian $\text{P}\text{M}\text{I}\text{Z}\text{E}$), $1 - 1 - \frac{1}{2} - 1$ (Hypophrygian $\text{P}\text{M}\text{I}\Theta\Gamma$, Phrygian $\text{Π}\text{M}\text{I}\Theta\Gamma$), $1 - \frac{1}{2} - 1 - 1$ (Hypodorian/Dorian $\text{Π}\text{M}\Lambda\text{H}\Gamma$); chromatic and enharmonic accordingly. It emerges that the old triad Dorian – Phrygian – Lydian is entirely covered together with their ‘Hypo’ scales.

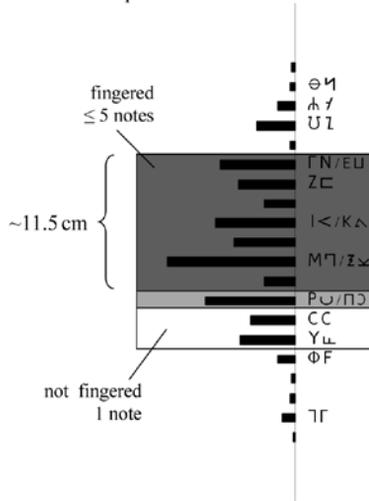


Fig. 4: The highest playing range of the modulating *aulos*

So much for the highest range. To obtain data for the bass region, as well, we start from a musical document. P.Vindob. G 13763/1494 (*DAGM* 15-16) is dated to the third or second century BC, thus belonging to the earliest surviving scores. It stands out by containing an instrumental interlude between vocal parts. Most interestingly, the sung and the instrumental parts make use of quite dissimilar scales, although in the same Hypolydian *tonos*. The vocal line remains within the octave from R to E, corresponding to about modern *d – d'*, divided according to the chromatic genus. The instrument appears to maintain the same upper limit, U in instrumental notation, but it goes three tones lower, although in a simpler scale, of undefined genus or perhaps diatonic¹⁷: see Figure 5.

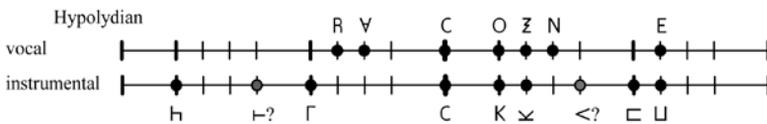


Fig. 5: Notes of *DAGM* 15-16.

¹⁷ Depending on whether the instrumental lines of n. 1494 with < belong to the same piece, and whether l. 7 ϩ is correctly identified as a note at all.

The highest note in both parts is that of our hypothetical *aulos*, which makes it plausible that the composition is intended for such an instrument. From the top note the continuous melodic scale reaches down to C, comprising no more than five + one notes, just as predicted for the *aulos*. This melodic scale is exploited in the first extant instrumental line, in a beautiful rolling motion (Figure 6.2). Below C, in contrast, we encounter no such melodic flow. In the second line, the bass notes are instead reached by plunges over large intervals, an empty fifth followed by a fourth, an ascent of an octave, again a fifth down, and finally a rising fourth (Figure 6.3). For this obvious difference between a melodic upper range and widely spread bass notes, establishing merely a sort of resonant skeleton scale, an organological explanation suggests itself: this is just what we would expect from an *aulos* equipped with a slider system in the bass region.

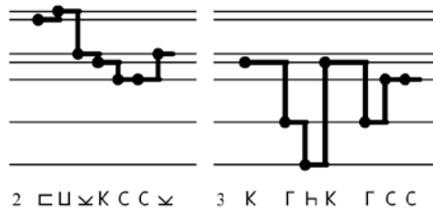


Fig. 6: Two fragmentary lines with instrumental notation in DAGM 15

Although a number of *aulos* sliders have been unearthed, all of the respective instruments were too fragmentary to permit a study of their tonal structure. Nevertheless, a find from Pergamum, probably dating from the second century BC, gives us an impression of how sliders and their holes could be distributed along a tube and in relation to its fingered part. The artefact, however, whose upper end is unfortunately missing, was no functional instrument, but a model, perhaps a votive offering¹⁸. Consequently we cannot expect it to reflect musically important measurements with precision; but it certainly preserves the

¹⁸ CONZE 1902, 7-8 with Taf. 1 (reproduced in WEST 1992, 88, Fig. 4.1; BYRNE 2002, 372, Fig. 1); photograph in BEHN 1954, Taf. 58, Abb. 134, together with a mistaken reconstruction. Cf. BYRNE 2002. Byrne sees «no reason not to take it as part of an actual instrument» (367), overlooking the fact that the artefact is solid, i.e. lacks a bore.

general proportions of a contemporary real pipe. This kept in mind, we can compare its design with our predictions.

The upper part of Figure 7 presents the theoretical measurements of an instrument on which the notes of *DAGM* 15-16 could be played. For better comparison, the tube and finger hole diameters of the Pergamum model are used; for the main bore, a diameter of 12 mm is tentatively assumed (variation within a few millimetres in this parameter does not affect the conclusions); within the functional tetrachords, a division of $\frac{3}{4} - \frac{3}{4} - 1$ tones was used (this concerns merely the placement of the four highest holes)¹⁹. Below this hypothetical instrument, drawings of the Pergamum model in three different views are printed in scale. It emerges that the crucial data are practically identical: the extension of the tube beyond the lowest melodic hole (C), the rough distribution of the slider holes, and the general magnitude of the interhole spacing in the melodic range.

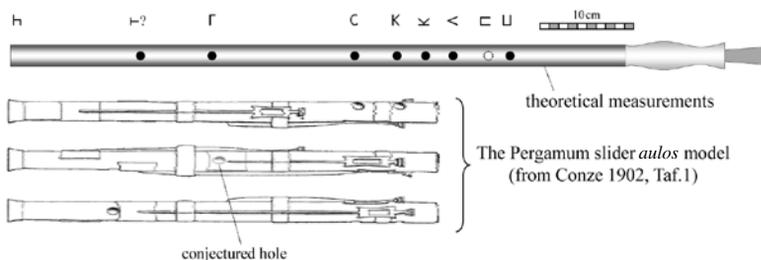


Fig. 7: A pipe for *DAGM* 15-16.

Of the Pergamum model's three slider holes, the lowest has no correspondence in *DAGM* 15-16. The second lowest very roughly matches H?, whose presence in the fragment is however doubtful. The highest slider rod extends right into the region of Γ – but for whatever reason, the rod lacks its plate. The intended position of the plate can however be reconstructed from the other two, and so can that of the imaginary hole that it would cover (cf. the greyed supplements in Figure 7). The position of the rod as well as the absence of a hole make it clear that the slider is represented in 'shut' state, i.e. pushed downwards (that a model would not contain a fake hole beneath a plate is obvious). In

¹⁹ Cf. WEST 1992, 97-100. Proper effective length and finger hole locations were calculated by the software described in HAGEL 2004.

this position, the upper end of the hole comes to lie a little below the point of the rod, which was in turn attached to the centre of the plate (the upper half of the plate merely ensures the alignment of plate and rod)²⁰.

That the pipe is reasonably reconstructed to an effective length as required by our theory, and that it plays the required pitches, is confirmed by M. Byrne's independent evaluation, who also concluded that an octave should be assumed between entire pipe and second finger hole²¹.

I should add that the model shows no signs of rotating sleeves. This may be explained by the fact that, in order to play a piece like *DAGM 15*, it would probably suffice to have the highest holes provided with sleeves, i.e. those holes which resided on the lost part of the Pergamum model; the lowest ones could always be stopped with the fingers.

Of course, we need not assume that the model was manufactured after an instrument that was identical in make with that for which *DAGM 15* was composed; the distance between the second and third finger hole, if not just resulting from artistic carelessness, indicates otherwise; perhaps also the second slider hole. But there remains

²⁰ The scope of the slider operation is hardly larger than the vertical hole diameter, as the slots on the upper part of the rods demonstrate: apparently the slider motion was restrained by means of small protrusions on the tube which projected into the slots. Therefore, the actual play of the slider equalled the slot length minus the vertical diameter of the protrusion, which was unlikely very much larger than its horizontal dimension, and certainly not shorter, since it resisted primarily vertical forces. In any case we obtain a minimal and a maximal value: the hole diameter, and the slot length. In Figure 7, the position of the hole is drawn right in the middle between these extremes. This corresponds to a protrusion length between 3 mm and 10 mm, depending on the assumed slot length. In comparison with the two others, the slot belonging to the highest hole is almost certainly too long on the model, as there is no reason to have slots of divergent length (for a hypothetical oversize oblong hole that gave two consecutive semitones, the slot is too short, and there is too little space between the plate and the bands above it). A protrusion length of not more than about 5 mm seems therefore most realistic.

²¹ BYRNE 2002, 368; 373, Ex. 1, with pitches rounded to the nearest modern semitone. If the effective length is chosen to yield the said octave, the distances between the finger holes would then amount to tones (calculated 195 and 200 cents respectively), and the lowest finger hole (open) would sound a pitch of about 179 Hz (f^{+47}) – precisely the generally assumed pitch of C C (between f and $f^\#$).

hardly any doubt that both instruments shared the characteristics we had predicted on theoretical grounds: a melodic range merely down to C C , with a small selection of additional bass notes. The fact that this general type of instrument left its traces in all kinds of sources – music theory, the extant melodies, and the scanty archaeological record – illustrates its central status in the world of the professional musician of the Hellenistic period.

Conceivably, the bass notes were different on different subtypes of the *aulos*. In DAGM 15, the two certain ones notably instantiate the fixed notes of the Hypolydian scale below *mesē* C C , namely *hypatē mesōn* $\Gamma\Gamma$ and *hypatē hypatōn* WH . This is a further indication of the connection between the Perfect System of ancient theory and the art of the *aulos*, which I have argued earlier on different grounds²².

Before concluding, it remains to inspect the relationship of our reconstructed instrument type and some more musical documents in greater detail. First, Limenius' Delphic Paean (DAGM 21), performed in the second half of the second century BC. Its text mentions the simultaneous accompaniment of the paean by the *aulos* and the *kithara*²³, and although this is embedded in an account of the mythical origins of the genus, one can hardly doubt that the same musical constellation was part of the present performance, as well. A look at the extant notes reveals that 89% of the vocal melody remains within what we may call either the top playing range of the modulating *aulos*, or the melodic region of the slider *aulos* (Figure 8). Three higher notes are also used, but only in specific contexts: Together they occur only in the shrill melody that describes the Galatian assault (ll. 31-33); F is in fact restricted to this context. L also appears in the first section, which is archaic and apparently citharodic in character (I shall argue elsewhere that this note was available as a *kithara* string), but otherwise only twice, obviously underscoring mention of the performers and their music²⁴. Finally, N is employed only twice outside the Galatian part, once to mark the god's arrival at the composer's home city (l.

²² HAGEL 2005.

²³ DAGM 21, 15 f. The *aulos* is clearly present in $\mu\epsilon\lambda\acute{\iota}\pi\nu\omicron\omicron\nu\omicron\delta\epsilon\ \Lambda\acute{\iota}\beta\upsilon\varsigma\ \alpha\upsilon\delta\acute{\alpha}\gamma\ \chi\acute{\epsilon}\omega[\nu\dots]$; the restitution of the *kithara* in a following lacuna is probable with view to the close parallel in DAGM 20, 14-16.

²⁴ The instances are: l. 15 on $\Lambda\acute{\iota}\beta\upsilon\varsigma$, geographical epithet for the *aulos*; l. 38 on the imperative $\mu\acute{\omicron}\lambda\epsilon\tau\epsilon$ within the final prayer, distinguishing the plea for the musicians from those for the Delphians and the Romans.

14), once – probably – illustrating the steeply rising precipice of the Parnassus (l. 23). As regards the notes below the prime auletic range, **F** appears only at two places. In one, the context is unclear (l. 25 f.); in the other, the note is associated with the Roman occupants (l. 39).

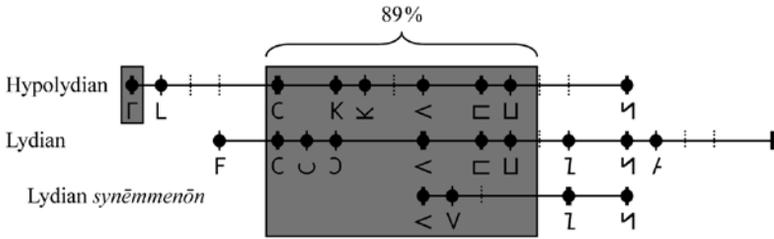


Fig. 8: The tonal material of Limenius' Delphic Paean (DAGM 21)

Especially intriguing is the case of the two lowest notes of the song. Although they are only a semitone apart, they do not enter a melodic relationship. **L** is introduced first at a place right after the focus has shifted from mythical narration to the present performance. It emphasises the adjective *θυρσοπλήξ*, «thyrsus-stricken», which provides the most vivid Dionysiac association in the entire piece (l. 20). Here the performers underline their identity as the Guild of Dionysus²⁵, apparently alluding to their non-Apollinic capacities, which threaten to break through at the mere mention of their Bacchic background. Another instance is doubtful. If correct, **L** carries here the monosyllabic imperative that calls for Apollo's epiphany on the mountain ridge (l. 22); the note would be separated from its neighbours by huge leaps of sevenths. But perhaps it is just an error for **♭**.

On the other hand, **Γ** is commonly used: compare its 16 occurrences with the 3 of **L** or the 6 of **F**. As a consequence, **Γ** is not connected with the main range melodically; it is invariably reached by momentary plunges, often over large intervals²⁶. We have met a similar technique in the second instrumental line in DAGM 15. Since the note involved is the same, and since a corresponding hole was also present on the instrument after which the Pergamum model was built, the conclusion is almost inevitable that these plunges in Limenius' com-

²⁵ For comparable techniques in Athenaeus' Paeon, cf. HAGEL 2002.

²⁶ We find five octaves with **□**, two fourths with **C**, two fifths with **K**, two minor sixths with **∞**, three minor ninths with **♭**, and, probably, an eleventh with **♯**.

position derive from auletic convention, ultimately rooted in instrument design²⁷.

Both DAGM 15 and Limenius' Paean are notated in the Lydian triad of keys, and so are other early documents. Some, however, adhere to the Phrygian keys. In these, the pitch of C C is of little importance; consequently the melody typically goes a semitone lower, to $\text{Y } \underline{\text{L}}$ ²⁸. It appears that this was the typical way of notating the complicated modulating figures of the so-called 'New Music', much of which worked within a semitone grid. The tonal material of the Ashmolean Papyri inv. 89/B 29-33 (DAGM 5-6), for instance, consists of no fewer than ten notes arranged in consecutive semitones ($\text{Y T } \Pi \text{ N M } \Lambda \text{ I } \Theta \Delta \Gamma$). Significantly, this sixth is identical with the highest playing range of the modulating *aulos*; an original accompaniment by such an instrument is therefore plausible. Here, however, the player must have made extensive use of the rotating sleeves. The details of melodic progression mostly escape us because of the fragmentary state of the papyrus. It seems, however, that various constellations of notes instantiate chunks of regular scales, chromatic, diatonic, and what is often called a kind of enharmonic without quartertones, between which modulation is frequent. Figure 9 illustrates possible and actually used scale fragments for the lower six notes in the gamut – the few instances of the higher notes forbid an analysis. It is obvious that such music required 'chromatic' instruments in the modern sense of the word (although not necessarily implying equal temperament).

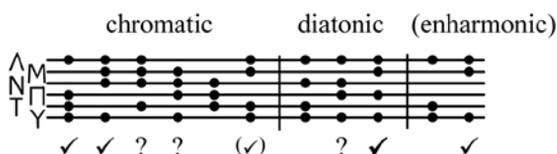


Fig. 9: Scale fragments in DAGM 5-6

²⁷ Whether lower slider notes were also used, we cannot know: the notation produces merely the vocal line, which did not descend below Γ (about modern *c*; on the ancient preference for high-pitched song, cf. WEST 1992, 42, 46, 276).

²⁸ The Phrygian pitch complement of C C appears only as chromatic $\text{T } \text{F}$, while the pitch of $\text{Y } \underline{\text{L}}$ is common to all three genera (in the enharmonic notated as $\text{T } \text{F}$).

Another example for this musical style, although in a less extreme form, is the second section of the other Delphic Paean, by Athenaeus (*DAGM* 20). Here we have the melody virtually complete, so that the technique of modulation can be studied²⁹. The second half of the section is of special interest, since it addresses the ongoing musical performance, mentioning first the *aulos*, and afterwards the *kithara* (ll. 14-16). It has long been seen that the conjunct undulating melodic movement imitates the typical sound of the woodwind, its «wriggling melodies» (*αἰόλοις μέλεσιν*)³⁰, which are only briefly interrupted by larger intervals, invoking the *kithara*, right when it is mentioned (cfr. Figure 10). Here, and only here, the vocal ambitus, which elsewhere covers more than an eleventh, narrows down to the space between Υ and Γ, which we could identify as the auletic main playing range. Again, instrumental practice has been taken into account by the composer, providing musical structures he could consciously allude to, and which he probably expected the audience to recognize. Significantly, the rearrangement of notes to different scale fragments also occurs only in this second, auletic and ‘Dionysian’ section of the piece (cfr. Figure 11).



Fig. 10: *DAGM* 20, 14-16 (λιγὺ δὲ ... ἀναμέλπεται)

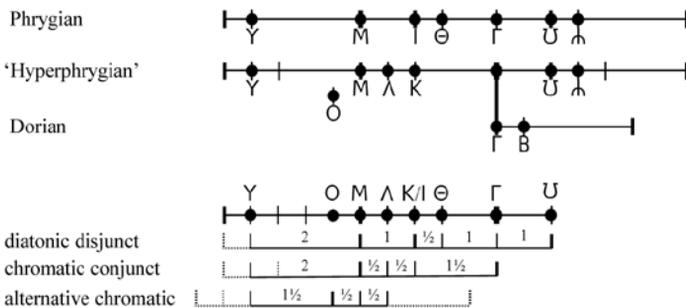


Fig. 11: Modulation in *DAGM* 20, 9-16

²⁹ Cf. HAGEL 2000, 38-76.

³⁰ On the programmatic features of the Delphic Paeans, cf. e.g. PÖHLMANN 1960, 65-70.

At this point of the presentation, the author presented a working model of an aulos built according to the conclusions reached so far, equipped with both sleeves and sliders. He played the melody of Figure 10 on one pipe with the help of the rotating sleeves, together with an accompaniment on the other pipe³¹.

Let us conclude by summing up the results that appear reasonably certain. Some prominent professional *aulos* type of the Hellenistic era played typically between a top note ΕΛ / ΓΝ and a bottom note either CC or ΥΛ, depending on the *tonos* used. In addition, ΤΓ and, at least sometimes, even lower 'slider' notes were available for momentary plunges. It is however very probable that there was not only one rigid instrument design, but several or many variants following this general standard.

Vocal compositions by no means restricted themselves to the ambitus of the instrument. When vocal and instrumental range (and melody, as probably in the last example discussed) coincided, this could be part of the composer's plan. Otherwise some sort of more extensive heterophony was necessarily adopted.

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³¹ The sound example is available on the Internet: <http://www.oeaw.ac.at/kal/agm>.

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