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TABLES OF GRAPH SPECTRA

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We present a survey of tables of graph spectra and related graph invariants. We provide tables of graph angles for connected graphs up to 5 vertices and of algebraic connectivities for connected graphs up to 6 vertices.

0. INTRODUCTION

Producing computerized catalogues of graphs which contain data of various kind is a permanent activity within the research in graph theory. Part of the material is published in scientific publications in the form of various tables while the rest is used and distributed by electronic means. Catalogues and tables of graphs are very useful in research; they provide examples and counterexamples in various instances and can suggest new results.

The present paper is devoted to the published tables of graph spectra and related graph invariants. Tables of graph spectra have been surveyed in monographs [**24**], [**23**] and this paper provides some additions including a description of tables produced by the programming package GRAPH.

An interactive programming package, called GRAPH, an expert system for graph theory, was developed at the University of Belgrade, Faculty of Electrical Engineering, during the period 1980-1984. GRAPH was designed to support research in graph theory, among other things, by helping to pose, verify and disprove conjectures [**19**], [**20**], [**25**], [**26**], [**27**], [**28**], [**32**], [**35**], [**57**], [**76**].
System GRAPH is able to generate graphs and compute various graph invariants; thus to produce graph catalogues and tables. During the ten years of use of GRAPH several graph catalogues have been created gradually; for example, we have catalogues of connected graphs up to 8 vertices, of trees up to 11 vertices, of unicyclic graph up to 9 vertices, of selfcomplementary graphs up to 9 vertices, of regular graphs up to 10 vertices, of cubic graphs up to 14 vertices, of all coplanar

1991 Mathematics Subject Classification: 05C50 graphs etc. Of course, these catalogues are very modest when compared to existing computarized graph catalogues (see, e.g., [**69**]); the point is their existence in conjuction with a user's friendly software such as the system GRAPH. The experience in creating graph catalogues in an interactive way has been sumarized and generalized in [**57**]. See [**35**], Section 1, for additional data on tables produced by GRAPH.

The role of spectral invariants in ordering graphs (especially in tables: lexicographical ordering by eigenvalues or spectral moments) has already been described (see, e.g., [**23**], pp. 70-72).

Numerical data on spectra or related graph invarients of some particular graphs can be found in several mathematical, chemical or physical papers. For data regarding graphs contained in some families of cospectral graphs see, e.g., [**24**]. Such particular data will not be surveyed in the present paper; only biger amounts of data which could be considered as "tables" are taken in consideration.

Our survey of tables of graph spectra is divided into the following sections: 1. Connected graphs, 2. Trees and unicyclic graphs, 3. Regular graphs, 4. Distance-regular graphs, 5. Miscellaneous graphs, 6. Tables containing some specific data. Section 7 contains some new tables (graph angles and algebraic connectivities).

1. CONNECTED GRAPHS

Table 1 in [**24**] contains 30 (1 with two, 2 with three, 6 with four and 21 with five vertices) connected graphs with n vertices where $2 \leq n \leq 5$. The spectrum and characteristic polynomials, factored into irreducible factors over the field of rational numbers, are given for each graph. This table is taken from [**16**].

The table in [**29**] contains 112 connected graphs on six vertices. The graphs are ordered lexicographically by their spectral moments in non-increasing order. The pictures of graphs are given to show as much symmetry as possible. Planar representations are prefered or indicated. Several data such as the spectral moments, spectrum and its main part, coefficients of the characteristic and of the matching polynomial, numbers of circuits of length 3, 4, 5, 6, radius, diameter, chromatic number, vertex-connectivity, property of being a line graph and the identification number of the complement of the graph (reffering again to this table) are given for each graph. Data from this table gave rise to a theorem on the main part of the spectrum.

Note that a table of all graphs (including disconnected case) up to six vertices, without any data, is also given in [**47**].

In the appendix of [**23**] a table of all (853) connected graphs with seven vertices is given. The pictures, coefficients of the characteristic polynomials, spectrum and spectral moments are included. The graphs are ordered lexicographically by their spectral moments.

It is interesting to note that in [**39**] some conjectures posed by the programming package Graffiti [**37**] have been disproved with counter- examples found in tables of [**23**].

The paper [**59**] contains a list of all the graphs on 7 vertices (including disconnected graphs) and their characteristic polynomials.

2. TREES AND UNICYCLIC GRAPHS

Table 2 in [**24**] contain all (200) trees with up to 10 vertices. The pictures, the eigenvalues and the coefficients of the characteristic polynomials are listed.

In [**71**] and [**72**] the characteristic polynomials of trees with up to 10 vertices were published. There is no difference between these two tables. Eigenvalues of trees for $n = 2, 3, ..., 9$ are given in [**73**]. Characteristic polynomials for trees with 2,3,...,8 vertices are also given in [**16**]. The diagrams of all trees up to 10 vertices are given in [**47**] too.

Characteristic polynomials of paths P_n $(1 \leq n \leq 20)$ are given in [**89**], vol.I, p.55.

A graph G is called *endospectral* [**77**] if it contains vertices u and v such that vertex deleted subgraphs $G-u$ and $G-v$ are non-isomorphic but cospectral. Examples of endospectral trees are given in [**77**] while in [**60**] all endospectral trees on up to 16 vertices are listed. Note that u and v have the same vertex angle sequences (see Section 7 for the definition).

Diagrams of the 89 unicyclic graphs on eight vertices are given in the Appendix of [**33**]. They are ordered lexicographically by spectral moments. For each graph the eigenvalues, the first six spectral moments and coefficients of the characteristic polynomial are given.

Diagrams of the 240 unicyclic graphs on nine vertices are ordered lexicographically by their spectral moments in [**26**]. For each graph the spectrum, the spectral moments and the coefficients of the characteristic polynomial are given. Inspecting the data for these graphs one can see that the constant term of the characteristic polynomial belongs to the set $\{-4, -2, -1, 0, 1, 2, 4\}$. This gave the idea for a theorem which generalizes this fact [**26**].

3. REGULAR GRAPHS

In [**31**] a table of regular graphs with at most 10 vertices is given. There are exactly 250 regular graphs on at most ten vertices. A table of all these graphs, which contains several data on them, was produced by the system GRAPH. Several conclusions, implied by the data of the table are drawn. Each graph in the table is described by the following data, among others: spectral moments (second up to sixth), eigenvalues, coefficients of the characteristic polynomial, number of triangles, quadrangles and pentagons, diameter and radius, planarity. It was noticed that graphs with sufficiently high degree have the diameter equal to 2. This gives rise to a proposition explaining this fact [**31**]. Some observations concerning the lexicographical ordering of regular graphs (with fixed degree and the number of vertices) by spectral moments are described.

A table of all regular connected graphs with the least eigenvalue -2 which are not line graphs is given in [**7**] (see also [**8**]). There are exactly 187 such graphs. Each graph is given by the list of its edges (presented as pairs of vertices) and for each graph eigenvalues are given.

It is known that there exist 68 connected regular graphs, non-isomorphic but cospectral to line graphs. These 68 graphs are constructed in [**30**] by SEIDEL'S switching from the line graphs of some regular graphs on 8 vertices (15 graphs) or of some semiregular bipartite graphs on 9 vertices (2 graphs). The construction is given by a table in wich source graphs, switching sets and some invariants of the resulting graphs are given. These invariants (e.g. independent sets of 4 vertices) serve to check that resulting graphs are mutually non-isomorphic and non-isomorphic to line graphs. A lot of data from the tables were computed by the system GRAPH. In this way a computer is used to find a proof (of some facts) which does not use a computer!.

In [**11**] a complete list of minimal forbidden subgraphs for graphs with the least eigenvalue not smaller than -2 is given.

In [**5**] (see also [**6**]) the all of 621 connected cubic graphs with not more than 14 vertices are listed. The characteristic polynomial, spectrum, numbers of circuits of length 3,4,...,14, diameter, connectivity, order of the automorphism group and a statement indicating planarity are displayed.The sequence of eigenvalues is given in non-increasing order and for a fixed number of vertices the graphs are ordered lexicographically with respect to their sequences. There are 1 connected cubic graph with four vertices, 2 with six, 5 with eight, 19 with ten, 85 with twelve and 509 with fourteen vertices. Paper [**55**] provides pictures of the 509 cubic graphs on fourteen vertices and some non-spectral data.

Table 3 in [**24**], based on [**5**], contains connected cubic graphs with up to 12 vertices. The pictures, spectrum and coefficients of the characteristic polynomials are included.

Note that the paper [**75**] provided 86 connected cubic graphs with 12 vertices but two of them were isomorphic (see [**24**], p.268, for details). 19 connected cubic graphs with 10 vertices are displayed, also, in [**12**] and [**56**]. Computerized catalogues of cubic graphs are described in [**38**] (up to 18 vertices) and [**69**] (up to 20 vertices). No of these tables or catalogues contain data related to eigenvalues and that's why we have not included some other references on cubic graphs.

Tables of all transitive graphs with fewer then 20 vertices (1031 graphs) are given in 68]. The eigenvalues and many other data of these graphs are given. A list of all the graphs with at most 26 vertices and transitive automorphism group is completed in [**70**]. Although most of the construction was done by computer, substantial preparation was necessary. In the paper the method of construction is described and results are summarized. Transitive graphs with 24 vertices are constructed in [**78**].

4. DISTANCE-REGULAR GRAPHS

The survey paper [**54**] contains tables of parameters (including eigenvalues) for many strongly regular graphs which had been classified up to that time.

A more recent survey on the some topic is contained in [**2**].

The paper [**1**] contains a list of possible parameter sets of strongly regular graphs on 300 vertices and less. M. D. Hestenes (unpublished) computed such parameter sets for graphs up to 900 vertices, as noted in [**24**], p.197. All strongly regular graphs up to 28 vertices are known [**79**], [**1**]. For some parameter sets there are many non-isomorphic (but, of course, cospectral) strongly regular graphs. Such strongly regular graphs need not be switching equivalent (see Section 6.1 in [**24**]). In [**13**] 91 switching classes of strongly regular cospectral graphs on 35 vertices are found.

A.J. Paulus found in [**74**] a strongly regular graph on 26 vertices whose automorphism group is trivial. In the same paper seven regular graphs with 25 vertices are constructed such that each is cospectral with, but not isomorphic to, its complement. All fourteen graphs are cospectral. Their eigenvalues are 12, 2 and -3 with multiplicities 1, 12 and 12 respectively.

A table of all feasible parameter sets for primitive strongly regular graphs with strongly regular decomposition up to 300 vertices has been given in [**46**].

Papers [**9**] and [**10**] contain several data on two-graphs (for definition see [**24**] pp.199-203). These include two-graphs with integral spectra. A table of all nonisomorphic two-graphs on n ($n \leq 9$) vertices and a table of all non-isomorphic two-graphs on n ($n \leq 10$) vertices whose automorphism group does not fix any graph in its switching class are given in these papers. The two-graph is represented by its (-1,1,0)-adjacency matrix. Its eigenvalues and the order of the automorphism group are given. Some data on known regular two-graphs on n ($n \leq 50$) vertices are listed too.

The report [**4**] contains the tables of switching classes of signed graphs and the corresponding eigenvalues as well as tables of some related data.

The last chapter of the comprehensive book [**3**] contains tables of parameter sets for distance-regular graphs. Only intersection arrays are given which pass all known feasibility criteria. The tables contain parameters for primitive distance-regular graphs with diameter 3 on at most 1024 vertices, for non-bipartite distance-regular graphs with diameter 4 on at most 4096 vertices and for arbitrary distance-regular graphs of diameter at least 5 on at most 4096 vertices. Eigenvalues are given for each graph.

5. MISCELLANEOUS GRAPHS

Table 5 in [**24**] contains the characteristic polynomials and non-zero eigenvalues of graphs $K_{n_1,\ldots,n_k}$ $(n_1 + \cdots + n_k = n)$ for $2 \leq k \leq n \leq 10$. This table has been originally published in [**18**].

Table 4 in [**24**] contains the characteristic polynomials and eigenvalues of circuits (C_n), prisms with 2k $(k \geq 3)$ vertices, some cubic multigraphs, the smallest cubic graph of girth 6, the dodecahedron graph and some other graphs with 6,7,8,9 and 12 vertices. This table was compiled partly on the basis of data taken from [**16**]; part of the material was computed by L.L.Kraus and S.K.Simić.

Table 6 in [**24**] contains characteristic polynomials of graphs consisting of

1. a circuit C_r and a path P_s $(r = 5, 6, 7;\ 1 \leq s \leq 7)$ with a vertex of the circuit and an end vertex of the path in common;

2. two circuits C_r and C_s with an edge in common $(5 \leq r \leq s \leq 7)$.

This table was taken from [**48**].

In [**36**] coefficients of the characteristic polynomial of some hexagonal systems are obtained. A table of spectra of hexagonal systems (animals) is published in [**44**], [**45**]. Matching polynomials and their zeros are given as well. Tables of spectra of hexagonal systems are published also in [**49**], [**50**], [**51**], [**52**], [**81**], [**82**], [**83**], [**92**], [**93**], [**94**], [**95**], [**96**],[**97**].

In [**71**], [**58**] and [**53**] tables of characteristic polynomials and so-called *topological indices* of graphs were published. In [**53**] the nonadjacent numbers, i.e. the coefficients of the Z-counting polynomial , the topological indices , and the coefficients of the characteristic polynomial of heptahex graphs G are tabulated.

[**14**] contains characteristic polynomials and spectra of all connected subgraphs, having up to six vertices, of the sum of graphs P_m and P_n. Tables in [**24**] (Table 1) and [**29**] contain these graphs. [**16**] contains a table of characteristic polynomials of miscellaneous graphs. Majority of them are included in Table 4 of [**24**].

Two extensive books of tables [**17**] and [**80**] contain numerical values for spectra, eigenvectors, and some other quantities (which are of interest in chemistry in connection with total π-electron energies and bond orders, etc.) of a great number of graphs related to the most important chemical compounds. Heteromolecules (i.e., graphs whose adjacency matrix has some non-zero elements on the main diagonal) are also dealt with.

The appendix of [**41**] contains a small but very interesting table of cospectral graphs.

Paper [**42**] contains statistical data on cospectral graphs on up to 9 vertices and on cospectral trees up to 18 vertices.

6. TABLES CONTAINING SOME SPECIFIC DATA

A digraph is called *normal* if its adjacency matrix is normal [**84**]. Normal digraphs have complete system of mutually orthogonal (normalized) eigenvectors and therefore a normal digraph is completely determined by its eigenvalues and eigenvectors. Of course, all symmetric digraphs are normal. Hence, it is of interest to describe non-symmetric normal digraphs (briefly propre normal digraphs). A propre normal digraph without multiple arcs or loops is denoted by PND. It is shown in [**84**] that there are exactly 14 PND with at most 5 vertices. It is stated in [**65**] that there are 55 PND with 6 vertices and 267 PND with 7 vertices. Their adjacency matrices are listed.

In [**86**] and [**87**] A.Torgašev has described all finite and infinite connected graphs having 3, 4 or 5 non-zero eigenvalues (not necessary distinct). There are exactly 37 connected graphs with at most 5 non-zero eigenvalues (1 graph (K_2) with two , 1 graph (K_3) with three, 8 graphs with four and 27 graphs with five non-zero eigenvalues).

All finite connected graphs which have exactly 6 non-zero eigenvalues are described in [**64**]. There are exactly 1644 non-isomorphic canonical graphs with exactly 6 non-zero eigenvalues. (Two vertices are *equivalent* if and only if they are not adjacent and they have the same neighbours.The canonical graph of G is the corresponding quotient graph of G.) Their orders run over the set $\{6, 7, ..., 14\}$. A list of all (there are 27) maximal graphs (with respect to relation to be induced subgraph) is given. Any other canonical graph is an induced subgraph of these ones, or an overgraph of the corresponding basic graph (graph with 6 vertices and 6 non-zero eigenvalues -always induced, in the list, by the first 6 vertices of a maximal graph). The maximal graphs are represented by their adjacency matrices.

A complete list of 1644 canonical graphs with 6 non-zero eigenvalues is given in [**66**].

All connected graphs with exactly three negative eigenvalues are described in [**88**]. There are exactly 1800 nonisomorphic canonical graphs with exactly three negative eigenvalues. 32 of these graphs are maximal. They have orders between 9 and 14 inclusive.

All connected graphs whose energy (i.e. the sum of all the positive eigenvalues including also their multiplicities) does not exceed 3 are described in [**85**]. There are exactly 29 such graphs. All connected graphs whose energy does not exceed 4 are described in [**62**]. There are exactly 154 non-isomorphic connected graphs whose energy does not exceed 4 and is greater than 3. Their orders runs over the set $\{5, 6, ..., 17\}$. The adjacency matrices of all graphs are listed.

All connected graphs whose reduced energy (i. e. the sum of absolute values of all the eigenvalues except the largest one), does not exceed 5 are described in [**63**]. There are exactly 212 such graphs. Their orders run over the set $\{4, 5, ..., 11\}$. The adjacency matrices of all graphs are listed.

Table 7 in [**24**] contains all simple eigenvalues of graphs whose automorphism group has two orbits of degrees r_1, r_2 where $1 \leq r_2 \leq r_1 \leq 5$. (For definition see Section 5.1 in [**24**].) This table was published in [**61**].

Table 8 in [**24**] is in connection with the operation of Seidel switching (see Section 6.5 of [**24**]). The table is taken from [**67**]. The table contains equivalence classes under Seidel switching of graphs with n vertices, where $2 \leq n \leq 7$.

In [**90**] the eigenvalues of the matrix $A - D + (n-1)I$ (A adjacency matrix, D diagonal matrix of vertex degrees, I unit matrix) have been calculated for all graphs with up to five vertices.

Tables of characteristic polynomials of some infinite periodic plane graphs are given in [**15**]. These graphs include the 11 known regular plane coverings of Laves (see Chapter 6 of [**23**]).

7. SOME NEW TABLES

In this section we present some original tables. These are tables of *graph angles* and tables of *algebraic connectivity* of graphs. We start with some definitions.

Let G be a graph with vertices 1, ..., n. Let $\mu_1, ..., \mu_m$ ($\mu_1 > \cdots > \mu_m$) be the distinct eigenvalues of (the (0,1)-adjacency matrix $A = A(G)$ of) G, with corresponding eigenspaces $\mathcal{E}(\mu_1)$, ..., $\mathcal{E}(\mu_m)$. Let $\{e_1, ..., e_n\}$ be the standard orthonormal basis of R^n. The numbers $\alpha_{ij} = cos\ \beta_{ij}$ ($i = 1, ..., m$; $j = 1, ..., n$), where β_{ij} is the angle between $\mathcal{E}(\mu_i)$ and e_j, are called *angles* of G. The $m \times n$ matrix $\mathcal{A} = (\alpha_{ij})$ is called the *angle matrix* of G. We may order the columns of $\mathcal{A}$ lexicographically so that $\mathcal{A}$ becomes a graph invariant. Rows of $\mathcal{A}$ are associated with eigenvalues and are called *eigenvalue angle sequences*, while columns of $\mathcal{A}$ are associated with vertices and are called *vertex angle sequences*. The *main angles* of G are the cosines of the angles between eigenspaces of G and the vector whose all components are equal to 1. Angles were introduced in [**21**] (see also [**22**] and [**34**]).

For a graph G on n vertices let A be its adjacency matrix and let D be a diagonal matrix with vertex degrees of G on the diagonal. The second smallest eigenvalue of $D - A$ is called the *algebraic connectivity* of G (see [**40**] or [**24**], pp.265-266).

In Table 1 all connected graphs on n vertices ($2 \leq n \leq 5$) are given in the same order as in Table 1 in appendix of [**24**] together with relevant data. Table 1 in this paper contains, for each graph, eigenvalues (first line), main angles (second line) and vertex angle sequences refering to labels of vertices in the graph diagram which follows. Vertices of graphs in Table 1 are ordered in such a way that the corresponding vertex angle sequences are ordered lexicographically.

Table 2 contains algebraic connectivities for graphs in Table 1.

Table 3 refers to the table of 112 connected graphs on six vertices from [**29**] which is described in Section 1. Using identification numbers of graphs from [**29**] we give algebraic connectivities of the 112 connected graphs.

Table 1.
Eigenvalues, main angles and angles of connected graphs up to five vertices

1.		1.0000	-1.0000		
		1.0000	0.0000		
	1.	0.7071	0.7071		
	2.	0.7071	0.7071		
2.		2.0000	-1.0000^2		
		1.0000	0.0000		
	1.	0.5774	0.8165		
	2.	0.5774	0.8165		
	3.	0.5774	0.8165		
3.		1.4142	0.0000	-1.4142	
		0.9856	0.0000	0.1691	
	1.	0.7071	0.0000	0.7071	
	2.	0.5000	0.7071	0.5000	
	3.	0.5000	0.7071	0.5000	
4.		3.0000	-1.0000^3		
		1.0000	0.0000		
	1.	0.5000	0.8660		
	2.	0.5000	0.8660		
	3.	0.5000	0.8660		
	4.	0.5000	0.8660		
5.		2.5616	0.0000	-1.0000	-1.5616
		0.9925	0.0000	0.0000	0.1222
	1.	0.5573	0.0000	0.7071	0.4352
	2.	0.5573	0.0000	0.7071	0.4352
	3.	0.4352	0.7071	0.0000	0.5573
	4.	0.4352	0.7071	0.0000	0.5573
6.		2.1701	0.3111	-1.0000	-1.4812
		0.9695	0.1663	0.0000	0.1803
	1.	0.6116	0.2536	0.0000	0.7494
	2.	0.5227	0.3682	0.7071	0.3020
	3.	0.5227	0.3682	0.7071	0.3020
	4.	0.2818	0.8152	0.0000	0.5059
7.		2.0000	0.0000^2	-2.0000	
		1.0000	0.0000	0.0000	
	1.	0.5000	0.7071	0.5000	
	2.	0.5000	0.7071	0.5000	
	3.	0.5000	0.7071	0.5000	
	4.	0.5000	0.7071	0.5000	
8.		1.7321	0.0000^2	-1.7321	
		0.9659	0.0000	0.2588	
	1.	0.7071	0.0000	0.7071	
	2.	0.4082	0.8165	0.4082	
	3.	0.4082	0.8165	0.4082	
	4.	0.4082	0.8165	0.4082	

Table 1. (continued)

9.		1.6180	0.6180	-0.6180	-1.6180	
		0.9732	0.0000	0.2298	0.0000	
	1.	0.6015	0.3717	0.3717	0.6015	
	2.	0.6015	0.3717	0.3717	0.6015	
	3.	0.3717	0.6015	0.6015	0.3717	
	4.	0.3717	0.6015	0.6015	0.3717	
10.		4.0000	-1.0000^4			
		1.0000	0.0000			
	1.	0.4472	0.8944			
	2.	0.4472	0.8944			
	3.	0.4472	0.8944			
	4.	0.4472	0.8944			
	5.	0.4472	0.8944			
11.		3.6458	0.0000	-1.0000^2	-1.6458	
		0.9957	0.0000	0.0000	0.0930	
	1.	0.4792	0.0000	0.8165	0.3220	
	2.	0.4792	0.0000	0.8165	0.3220	
	3.	0.4792	0.0000	0.8165	0.3220	
	4.	0.3943	0.7071	0.0000	0.5869	
	5.	0.3943	0.7071	0.0000	0.5869	
12.		3.3234	0.3579	-1.0000^2	-1.6813	
		0.9861	0.0837	0.0000	0.1432	
	1.	0.5100	0.1378	0.7071	0.4700	
	2.	0.5100	0.1378	0.7071	0.4700	
	3.	0.4390	0.4294	0.7071	0.3505	
	4.	0.4390	0.4294	0.7071	0.3505	
	5.	0.3069	0.7702	0.0000	0.5590	
13.		3.2361	0.0000^2	-1.2361	-2.0000	
		0.9960	0.0000	0.0898	0.0000	
	1.	0.5257	0.0000	0.8507	0.0000	
	2.	0.4253	0.7071	0.2629	0.5000	
	3.	0.4253	0.7071	0.2629	0.5000	
	4.	0.4253	0.7071	0.2629	0.5000	
	5.	0.4253	0.7071	0.2629	0.5000	
14.		3.0861	0.4280	-1.0000^2	-1.5141	
		0.9567	0.2306	0.0000	0.1774	
	1.	0.5236	0.3610	0.0000	0.7717	
	2.	0.4820	0.2297	0.8165	0.2196	
	3.	0.4820	0.2297	0.8165	0.2196	
	4.	0.4820	0.2297	0.8165	0.2196	
	5.	0.1697	0.8435	0.0000	0.5097	
15.		3.0000	0.0000^2	-1.0000	-2.0000	
		0.9798	0.0000	0.0000	0.2000	
	1.	0.5477	0.0000	0.7071	0.4472	
	2.	0.5477	0.0000	0.7071	0.4472	
	3.	0.3651	0.8165	0.0000	0.4472	
	4.	0.3651	0.8165	0.0000	0.4472	
	5.	0.3651	0.8165	0.0000	0.4472	
16.		2.9354	0.6180	-0.4626	-1.4728	-1.6180
		0.9839	0.0000	0.0738	0.1629	0.0000
	1.	0.5590	0.0000	0.3069	0.7702	0.0000
	2.	0.4700	0.3717	0.5100	0.1378	0.6015
	3.	0.4700	0.3717	0.5100	0.1378	0.6015
	4.	0.3505	0.6015	0.4390	0.4294	0.3717
	5.	0.3505	0.6015	0.4390	0.4294	0.3717

Table 1. (continued)

17.	2.8558	0.3216	0.0000	-1.0000	-2.1774
	0.9898	0.1363	0.0000	0.0000	0.0416
1.	0.4912	0.3870	0.0000	0.7071	0.3301
2.	0.4912	0.3870	0.0000	0.7071	0.3301
3.	0.4558	0.1312	0.7071	0.0000	0.5244
4.	0.4558	0.1312	0.7071	0.0000	0.5244
5.	0.3192	0.8161	0.0000	0.0000	0.4817
18.	2.6855	0.3349	0.0000	-1.2713	-1.7491
	0.9602	0.1692	0.0000	0.0486	0.2170
1.	0.5825	0.2835	0.0000	0.4008	0.6478
2.	0.5237	0.3506	0.0000	0.7611	0.1534
3.	0.4119	0.2004	0.7071	0.2834	0.4581
4.	0.4119	0.2004	0.7071	0.2834	0.4581
5.	0.2169	0.8464	0.0000	0.3153	0.3704
19.	2.6412	0.7237	-0.5892	-1.0000	-1.7757
	0.9550	0.1833	0.2319	0.0000	0.0262
1.	0.5371	0.1655	0.1955	0.7071	0.3820
2.	0.5371	0.1655	0.1955	0.7071	0.3820
3.	0.4747	0.5030	0.3529	0.0000	0.6301
4.	0.4067	0.4573	0.6636	0.0000	0.4303
5.	0.1797	0.6950	0.5989	0.0000	0.3549
20.	2.5616	1.0000	-1.0000^2	-1.5616	
	0.9802	0.0000	0.0000	0.1979	
1.	0.6154	0.0000	0.0000	0.7882	
2.	0.3941	0.5000	0.7071	0.3077	
3.	0.3941	0.5000	0.7071	0.3077	
4.	0.3941	0.5000	0.7071	0.3077	
5.	0.3941	0.5000	0.7071	0.3077	
21.	2.4812	0.6889	0.0000	-1.1701	-2.0000
	0.9850	0.1223	0.0000	0.1220	0.0000
1.	0.5299	0.1793	0.5000	0.4325	0.5000
2.	0.5299	0.1793	0.5000	0.4325	0.5000
3.	0.4271	0.5207	0.0000	0.7392	0.0000
4.	0.3578	0.5765	0.5000	0.1993	0.5000
5.	0.3578	0.5765	0.5000	0.1993	0.5000
22.	2.4495	0.0000^3	-2.4495		
	0.9949	0.0000	0.1005		
1.	0.5000	0.7071	0.5000		
2.	0.5000	0.7071	0.5000		
3.	0.4082	0.8165	0.4082		
4.	0.4082	0.8165	0.4082		
5.	0.4082	0.8165	0.4082		
23.	2.3429	0.4707	0.0000	-1.0000	-1.8136
	0.9506	0.1587	0.0000	0.0000	0.2667
1.	0.6359	0.2414	0.0000	0.0000	0.7331
2.	0.4735	0.4560	0.0000	0.7071	0.2606
3.	0.4735	0.4560	0.0000	0.7071	0.2606
4.	0.2714	0.5128	0.7071	0.0000	0.4042
5.	0.2714	0.5128	0.7071	0.0000	0.4042
24.	2.3028	0.6180	0.0000	-1.3028	-1.6180
	0.9444	0.0000	0.2582	0.2035	0.0000
1.	0.5651	0.3717	0.0000	0.4250	0.6015
2.	0.5651	0.3717	0.0000	0.4250	0.6015
3.	0.4908	0.0000	0.5774	0.6525	0.0000
4.	0.2454	0.6015	0.5774	0.3263	0.3717
5.	0.2454	0.6015	0.5774	0.3263	0.3717

Table 1. (continued)

25.		2.2143	1.0000	-0.5392	-1.0000	-1.6751
		0.9370	0.2828	0.2021	0.0000	0.0347
	1.	0.6037	0.0000	0.4762	0.0000	0.6394
	2.	0.4972	0.3162	0.3094	0.7071	0.2390
	3.	0.4972	0.3162	0.3094	0.7071	0.2390
	4.	0.3425	0.6325	0.3620	0.0000	0.5930
	5.	0.1547	0.6325	0.6714	0.0000	0.3540
26.		2.1358	0.6622	0.0000	-0.6622	-2.1358
		0.9762	0.0742	0.0000	0.1835	0.0885
	1.	0.5573	0.4352	0.0000	0.4352	0.5573
	2.	0.4647	0.1845	0.7071	0.1845	0.4647
	3.	0.4647	0.1845	0.7071	0.1845	0.4647
	4.	0.4352	0.5573	0.0000	0.5573	0.4352
	5.	0.2610	0.6572	0.0000	0.6572	0.2610
27.		2.0000	0.6180^2	-1.6180^2		
		1.0000	0.0000	0.0000		
	1.	0.4472	0.6325	0.6325		
	2.	0.4472	0.6325	0.6325		
	3.	0.4472	0.6325	0.6325		
	4.	0.4472	0.6325	0.6325		
	5.	0.4472	0.6325	0.6325		
28.		2.0000	0.0000^3	-2.0000		
		0.9487	0.0000	0.3162		
	1.	0.7071	0.0000	0.7071		
	2.	0.3536	0.8660	0.3536		
	3.	0.3536	0.8660	0.3536		
	4.	0.3536	0.8660	0.3536		
	5.	0.3536	0.8660	0.3536		
29.		1.8478	0.7654	0.0000	-0.7654	-1.8478
		0.9530	0.0785	0.0000	0.2638	0.1267
	1.	0.6533	0.2706	0.0000	0.2706	0.6533
	2.	0.5000	0.5000	0.0000	0.5000	0.5000
	3.	0.3536	0.3536	0.7071	0.3536	0.3536
	4.	0.3536	0.3536	0.7071	0.3536	0.3536
	5.	0.2706	0.6533	0.0000	0.6533	0.2706
30.		1.7321	1.0000	0.0000	-1.0000	-1.7321
		0.9636	0.0000	0.2582	0.0000	0.0692
	1.	0.5774	0.0000	0.5774	0.0000	0.5774
	2.	0.5000	0.5000	0.0000	0.5000	0.5000
	3.	0.5000	0.5000	0.0000	0.5000	0.5000
	4.	0.2887	0.5000	0.5774	0.5000	0.2887
	5.	0.2887	0.5000	0.5774	0.5000	0.2887

Table 2. Algebraic connectivity of connected graphs up to five vertices

1.	2.0000	2.	3.0000	3.	1.0000	4.	4.0000	5.	2.0000
6.	1.0000	7.	2.0000	8.	1.0000	9.	0.5858	10.	5.0000
11.	3.0000	12.	2.0000	13.	3.0000	14.	1.0000	15.	2.0000
16.	1.5858	17.	2.0000	18.	1.0000	19.	0.8299	20.	1.0000
21.	1.3820	22.	2.0000	23.	1.0000	24.	0.6972	25.	0.5188
26.	0.8299	27.	1.3820	28.	1.0000	29.	0.5188	30.	0.3820

Tables 1, 2 and 3 were computed (in a "push the button" manner, of course) by the expert system "Graph".

Table 3. Algebraic connectivity of connected graphs on six vertices

1.	6.0000	2.	4.0000	3.	3.0000	4.	4.0000	5.	2.0000
6.	3.0000	7.	2.5858	8.	3.0000	9.	4.0000	10.	1.0000
11.	2.0000	12.	1.8299	13.	2.0000	14.	2.0000	15.	2.3820
16.	3.0000	17.	3.0000	18.	2.5858	19.	1.0000	20.	0.9139
21.	2.0000	22.	1.6972	23.	1.4384	24.	1.5188	25.	1.8299
26.	1.7857	27.	1.6972	28.	2.3820	29.	2.0000	30.	2.2680
31.	2.0000	32.	3.0000	33.	1.0000	34.	0.8929	35.	0.7639
36.	1.0000	37.	2.0000	38.	1.0000	39.	0.9139	40.	1.5188
41.	1.2679	42.	1.6972	43.	1.3820	44.	1.1864	45.	1.4384
46.	1.6072	47.	1.6972	48.	1.4384	49.	2.0000	50.	1.7857
51.	2.0000	52.	3.0000	53.	1.0000	54.	0.7639	55.	0.4859
56.	1.0000	57.	0.7639	58.	1.0000	59.	0.8851	60.	0.7312
61.	1.0000	62.	0.7639	63.	0.8929	64.	0.9139	65.	0.7639
66.	1.2679	67.	1.1088	68.	1.3820	69.	1.2679	70.	1.0000
71.	1.4384	72.	1.5858	73.	2.0000	74.	1.4384	75.	1.0000
76.	0.7639	77.	0.6972	78.	0.7639	79.	1.0000	80.	0.5858
81.	0.4859	82.	0.4384	83.	0.6314	84.	0.4384	85.	0.8817
86.	0.6972	87.	0.7216	88.	0.7639	89.	1.0000	90.	0.9139
91.	0.7639	92.	1.0000	93.	1.2679	94.	1.0000	95.	0.6314
96.	0.6972	97.	0.4859	98.	0.4131	99.	0.4384	100.	0.3249
101.	0.7639	102.	0.6571	103.	0.5858	104.	0.4384	105.	0.6972
106.	1.0000	107.	1.0000	108.	0.4859	109.	0.4384	110.	0.3820
111.	0.3249	112.	0.2679						

Note that in [**43**] a small table of algebraic connectivity of some trees on 7 and 8 vertices is given.

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Note added in proof. We have recently learnt that the following book should appear in 1994:

98. R. C. Read, R. J. Wilson: *An Atlas of Graph Theory.* Oxford University Press, to appear.

The book contains several graph catalogues and data tables. Concerning graph spectra, the book will contain characteristic polynomials and spectra of graphs up to 7 vertices, of trees up to 12 vertices, of cubic graphs up to 14 vertices, etc.

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