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Catalogue of Apparent Diameters and Absolute Radii of Stars (CADARS) – Third edition – Comments and statistics

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Abstract. The Catalogue, available at the Centre de Données Stellaires de Strasbourg*, consists of 13 573 records concerning the results obtained from different methods for 7778 stars, reported in the literature. The following data are listed for each star: identifications, apparent magnitude, spectral type, apparent diameter in arcsec, absolute radius in solar units, method of determination, reference, remarks. Comments and statistics obtained from CADARS are given.

Key words. catalogues – stars: fundamental parameters

1. Introduction

The first edition of the CADARS reporting data published up to 1979, appeared in 1981 (Fracassini & Pasinetti 1979; Fracassini et al. 1981b), and was installed in the CDS catalogue service as cat. II/61. Preliminary comments were reported by Fracassini et al. (1981a). Since then, a large amount of data appeared in the literature, many of them obtained from the modern interferometric techniques. The second edition, completely revised and updated, was CDS catalogue II/155 (Fracassini et al. 1988; Pastori et al. 1988) and was reported in "Selected Astronomical Catalogues", vol. 2, CD-ROM, ADC, NASA. Third edition, installed as CDS cat. II/224, consists of 13 573 records, more than twice the number of the first edition. Actually, the number of available data is higher as for many stars both the apparent diameter and absolute radius are given. Moreover, data obtained by the same author in different wavelengths are also given in the remarks. The records concern the results obtained from different methods for 7778 stars, including stars of the Magellanic Clouds and two neutron stars.

2. Classification of the methods

The methods for the determination of stellar dimensions were classified as direct or indirect methods. The direct methods are based on the observation of some physical phenomena *directly* correlated with the geometry of the stellar disks. The indirect methods are based on the observation of some physical parameters *indirectly* correlated with the geometry of the stellar disks. A more detailed subdivision is based on the physical principles of determination (Fracassini et al. 1981a). A recent discussion on the determination methods is given by Scholz (1997). Table 1 summarizes the classification adopted in the first edition of CADARS (Fracassini et al. 1981b) and in the updates. Column 1 reports the code number given in the Catalogue to each method of determination, Col. 2 the corresponding method, and eventually Col. 3 the reference of the first measure and/or *basic* paper. An adopted criterion was to restrict as much as possible the number of codes and to include in the same group all the methods based on similar fundamental principles. Therefore, only one code has been added in the third edition.

3. The catalogue

CADARS reports data appeared in the literature since 1950. However, fundamental and/or interesting data obtained before this year were also reported according to criteria given by Fracassini et al. (1981b). Third edition includes measures published from 1986 to 1997.

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* The Catalogue is available in electronic form at the CDS via anonymous ftp to `cdsarc.u-strasbg.fr (130.79.128.5)` or via
`http://cdsweb.u-strasbg.fr/cgi-bin/qcar?J/A+A/367/521`

Table 1. Classification of the methods and codes

DIRECT METHODS

CODE	METHOD	REFERENCES
1	Interferometer	Michelson, A. A., & Pease, F. G. 1921, ApJ, 53, 249
	Intensity interferometer	Hanbury Brown, R., Davis, J., et al. 1967, MNRAS, 137, 393
2	Diffraction	Arnulf, A. 1936, C. R. Acad. Sci. Paris, 202, 115
	Lunar occultations	Williams, J. D. 1939, ApJ, 89, 467
3A	Star scintillation – Color changes	Tichov, G. 1921, Mitt. Leshafts Inst. Leningrad, 2, 126
3B	Star scintillation – speckle interferometry	Gezari, D. Y., Labeyrie, A., & Stachnik, R. V. 1972, ApJ, 173, L1
4	Eclipsing and spectroscopic binaries	Russell, H. N. 1911, ApJ, 35, 315
		Lehman-Filhés, R. 1894, Astron. Nach., 130, 17
5	Pulsating stars	Van Hoof, A. 1945, Publ. Lab. Astron. Géodés., Univ. Louvain XI, 100
5A	Pulsating stars	Wesselink, A. J. 1946, Bull. Inst. Netherlands, X, 91
5B	Pulsating stars	Balona, L. A. 1977, MNRAS, 178, 231
5C	Pulsating stars	Methods which cannot be included in the groups 5, 5A, 5B

INDIRECT METHODS

CODE	METHOD	REFERENCES
6A	Intrinsic brightness and color	Pickering, E. C. 1880, Proc. Amer. Acad. Arts Sci., 16, 1
6B	" "	Russell, H. N. 1920, PASP, 32, 307
6C	" "	Hertzsprung, E. 1922, Ann. Leiden, XIV, 1
6D	" "	Pettit, E., & Nicholson, S. 1928, ApJ, 68, 279
6E	" "	Chalonge, D., & Divan, L. 1950, C. R. Acad. Sci. Paris, 231, 331
6F	" "	Fracassini, M., & Pasinetti, L. E. 1967, Atti XI Riunione SAIt. Padova
	" "	Fracassini, M., Gilardoni, G., & Pasinetti, L. E. 1973, Ap&SS, 22, 141
6G	" "	Gray, D. F. 1967, ApJ, 149, 317
	" "	Blackwell, D. E., & Shallis, M. J. 1977, MNRAS, 180, 177
6H	" "	Wesselink, A. J. 1969, MNRAS, 144, 297
6I	" "	Barnes, T. G., & Evans, D. S. 1976, MNRAS, 174, 489
6K	" "	Leone, S. 1978, Atti Acc. Sci. Lettere, Arti Palermo, Ser. IV, 35, 21
6L	" "	Walker, H. J., & Schönberner, D. 1981, A&A, 97, 291
6M	Fundamental stellar parameters	Various authors

The stars are listed according to the following order of identification: HD number, DM number, variables with constellation name in alphabetical order of the abbreviations, other identifications in alphabetical order, LMC and SMC stars, neutron stars at the end of CADARS (included only in the case of data derived from more or less direct measures). For the nomenclature of the stars see Fracassini et al. (1981b, Table II) and/or SIMBAD. At least one identification is that from the author. The catalogue is followed by the lists of the remarks and references. The columns of CADARS are the following:

1. Identifier: HD number (first priority); DM number (secondary priority); constellation name in alphabetical order (variable stars), when HD or DM numbers are not available; other identifications;
2. Bayer or Flamsteed designation or other identification; G and S indicate the components of a binary system;
3. Apparent visual magnitude given by the authors, otherwise by SIMBAD; variable stars: magnitude at maximum luminosity; remarks (W) specify magnitudes in other wavelengths;
4. Spectral type and luminosity class given by the authors, otherwise by SIMBAD;
5. Apparent diameter (arcsec) of the uniform disk; remarks specify other cases and/or values corrected for the limb darkening (L). Three significant figures are given; values given with more figures are reported in remarks. Errors (E) are given in remarks for uniformity with the previous versions;
6. Absolute radius (solar units). Three significant figures are given. Errors in remarks. For the Cepheids (code 5, 5A, 5B): averaged absolute radius given by the authors;
7. Method of determination (see Table 1 for the codes);
8. Source by an alphanumerical code. 1st digit: initial of the first author. 2nd digit: progressive number (see references);
9. Remarks. In the file of the remarks the star identifier is followed by the code of the source. Remark codes:
   (a) B Spectroscopic binary;
   (b) D Double star;
   (c) G Cluster, group, aggregate or association membership;
   (d) *R* Value of the apparent diameter and/or absolute radius corrected for the interstellar reddening. This remark is not used for the values from method 6F, all corrected for the reddening;

Table 2. Number of stars measured by one or more methodologies

Method	1	2	3	4	5	6	7	8	9
Stars	5805	1269	437	178	59	15	8	6	1

10. Codes calling attention to the file of the remarks:
    (a) A General characteristics;
    (b) E Mean error of the apparent diameter and/or absolute radius;
    (c) *L* Value in the catalogue obtained by a particular law of limb darkening specified by the authors; Remarks give other values of the uniform disk and/or values corrected for the limb darkening. Details on this problem were outlined by Scholz (1997);
    (d) W Wavelength (or bandwidth) of measurement of apparent diameter and/or absolute radius and/or apparent magnitude when different from the visual one.

4. Statistics and comments

The statistics which follow will give a general view on the acquisition and the contents of the material gathered for this catalogue. The data added in the third edition concern 1062 stars; only 523 stars, however, are new entries. Considering that the first edition reported 4266 stars, 6313 records, we can remark that the acquisition of data has developed faster in the second edition (1979–1985, 7255 stars, 12 055 records) than in the third one (1986–1997). The number of data reported with an estimate of the error increases from 9% in the first edition to 11% (IIed.) up to 15% in the third edition. However, the error is given in about 45% of the data added in the third edition (*new data*). Table 2 gives the number of stars measured by one or more methodologies.

The panels of Fig. 1 give the number of stars as a function of the apparent magnitude for the whole sample of stars and for only the *new data*. The magnitudes range from −1.5 down to 18.2. The comparison shows significative differences; while the histogram of Fig. 1a roughly reflects the natural frequency of the bright stars, influenced also by the difficulty for several methods to measure faint stars, the histogram of Fig. 1b is more influenced by the scientific interests of the authors and by the potentialities of new technologies. Maxima correspond to magnitude 4, 9, 12 instead of 4, 5, 6. The measured stars with $m > 12$ are increased up to 16% in the *new data* while, considering the global number of data, they are about 6% and 5% in the third and second edition, respectively. Of course, the *new data* are also affected by the absence of determinations made by some methods (6F, which strongly affected the statistics of the previous editions, and 5). For analogous causes, M stars, white dwarfs and F stars are the most numerous among the *new data* instead of B, A, K types as in the whole sample (see also previous editions of CADARS). In particular, the maximum at the A-type reflects the natural frequency of the stars, biased also by the high number of stars measured by the method of Fracassini & Pasinetti (1967, 1973) around this spectral type. The luminosity class is available in 76% of the stars. Their distribution is as follows: I–II class 654 stars, III 1227, IV–V 4057.

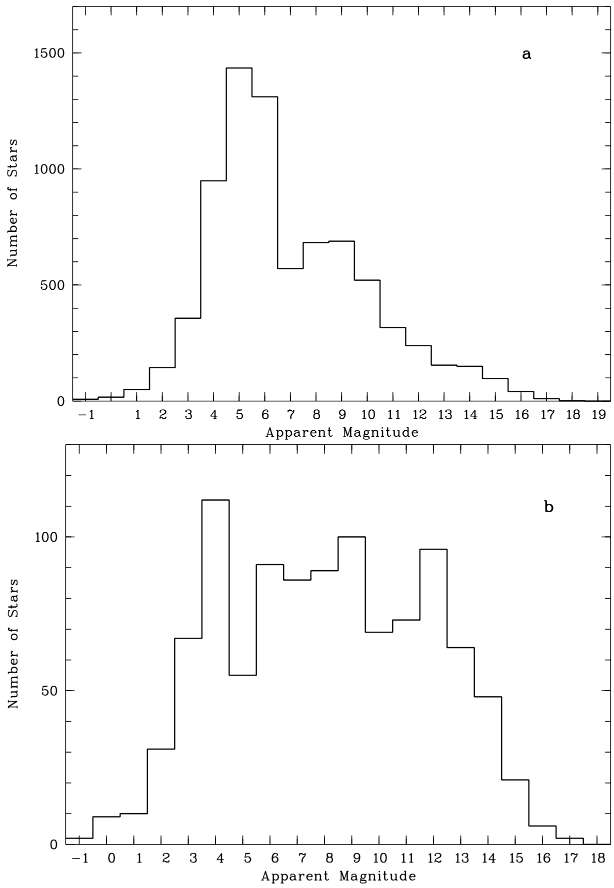

Fig. 1. Number of stars as a function of the apparent magnitude for the whole sample of stars (panel **a**)) and for the *new data* (panel **b**))

The methods 5, 6C, 6D, 6F, 6K, 6L were not utilized in the last decade. The new code 6M includes 14% of the *new data*. The most utilized direct method is that of the eclipsing and spectroscopic binaries. The interferometric measurements are about doubled from the IInd to IIIrd edition (0.6%, 1.2% respectively) while in the *new data* their percentage is roughly comparable to that of binary stars (7.4% and 9.3% respectively). The limits of magnitude and spectral type for each method (discussed by Fracassini et al. 1981a; Pastori et al. 1988) are not significantly changed from the II to III edition.

Finally, we have considered the problem of the errors of determination which may be useful in the tests for new instruments or other scientific applications. Table 3 gives for the principal methods the percentage of measures reported with values of the errors less than 1%, 5%, 10%. The last two columns give for each method the minimum

Table 3. Percentages of data with errors less than 1%, 5% and 10% for the different methods. (r): error on the absolute radius; (θ): error on the apparent diameter. Last two columns: minimum error of measure and related reference

Method		$\epsilon < 1\%$	$\epsilon < 5\%$	$\epsilon < 10\%$	min ϵ	Ref.
1	θ	8.2	39.5	78.0	0.6	M21
2	θ	3.5	23.6	47.1	0.1	Q3
3B	θ	0.0	25.9	55.6	2.0	L4
4	r	8.4	63.5	81.4	0.1	C11
5	r	5.2	39.7	81.0	0.8	F9
5A	r	0.2	22.1	52.9	0.7	M17
5B	r	3.1	76.9	93.9	0.6	B20
6G	r	0.3	2.6	45.5	0.8	P30
6G	θ	22.0	81.7	95.4	0.3	R13
6H	r	0.0	8.5	37.9	1.3	C34
6I	r	0.0	4.4	67.4	3.0	M23
6I	θ	2.3	28.1	58.4	0.5	B13
6M	r	33.0	66.7	66.7	0.4	S36

error of measure reported in CADARS and the relative reference according to the used codification. As expected, if we consider only direct methods, methods 4, 1, 5, 2 (in order of percentage) are predominant for $\epsilon < 1\%$. Moreover, among all the data, the lowest value of error was obtained from the method 2 (diffraction–lunar occultation) followed by 4 (binaries) and 1 (interferometer). To test the improvement of the measures during the last decade, we have reported in Table 4 the minimum error of determination listed in the IInd and IIIrd editions for some stars reported by Pastori et al. (1985). With the exception of HD 102212 and HD 156247 the improvement is remarkable.

Table 4. Minimum errors determined in some stars by direct methods and related references

HD	met.	II	III	Reference
29139	1	2.0	0.7	D10; Q2
48915	1	2.3	1.4	H9; D16
61421	1	6.8	1.0	H9; M21
124897	1	5.7	1.0	C15; D15
148478	1	12.1	2.0	W22; S34
213306	5A	7.5	2.3	I7; T5
102212	2	2.9	2.9	S17; S35
223075	2	2.4	0.6	B2; R28
34364G	4	5.6	2.0	C11; N10
34364S	4	5.6	2.0	C11; N10
40183G	4	3.2	1.1	K2; N9
156247G	4	1.2	1.8	C11; H21
156247S	4	3.3	1.7	C11; H21
218066S	4	4.3	2.4	C11; C26

5. Conclusions

The quality of the measures reported in CADARS is noticeably improved as shown by the percentages of data obtained from direct methods, about 12% and 15% in the IInd and IIIrd edition respectively. This percentage increases up to 41% if we consider only the *new data*. Among the spectral types, the highest increase of measurements corresponds to the WDs (about 32%), as it could be expected. Among the new data, the number of WDs is about equal to that of M stars reflecting the efficiency of new technologies. Considering the new data and those of the IIIrd and IInd edition, we find that M stars are about 21%, 16%, 12% respectively, and WDs 20%, 5%, 4%. It is also increased the percentage of faint stars, while the improvement of the measures is shown by the percentage of data given with an estimate of the error and by the lowering of the error values.

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