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A catalogue of Mg_2 indices of galaxies and globular clusters*

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Abstract. We present a catalogue of published absorption-line Mg_2 indices of galaxies and globular clusters. The catalogue is maintained up-to-date in the HYPERCAT database. The measurements are listed together with the references to the articles where the data were published. A coded description of the observations is provided. The catalogue gathers 3541 measurements for 1491 objects (galaxies or globular clusters) from 55 datasets. Compiled raw data for 1060 galaxies are zero-point corrected and transformed to a homogeneous system.

Key words: galaxies: galaxies: general — galaxies: star clusters — galaxies: stellar content

1. Introduction

Observations of several spectral indices and their calibration had led to a deeper insight of their dependence on the chemical history of stellar populations of the galaxies and globular clusters. A lot of observational work was concentrated on the strong absorption feature of Mg around 5175 Å. The most widely measured parameter is the Mg_2 index which describes the flux deficit at the region of Mg H and Mg I *b* triplet compared with the neighboring continuum.

To date, among the most comprehensive examples of such works are the studies of:

- 7 *Samurai* (Davies et al. 1987 - hereafter 7Sam, and Faber et al. 1989) for 479 galaxies;
- Jørgensen et al. (1995 - hereafter JFK95) with new data for 182 galaxies and recalibrated data for 90 galaxies;
- Jørgensen (1997) with Mg_2 data for 222 E and S0 galaxies in total;
- Lucey et al. (1997) with 141 new measurements for 78 galaxies and recalibrated data for 72 galaxies; and
- Smith et al. (1997) with Mg_2 data for 137 galaxies.

Most recently the full Lick/IDS (Image Dissector Scanner) database of Mg_2 indices for 381 galaxies and 38 globulars were published by Trager et al. (1998 - hereafter Lick98).

The purpose of this work is to gather all measurements of the Mg_2 index available and, when it is possible, to transform them after appropriate corrections to a standardized homogeneous system.

The Mg_2 index definition introduced initially by Faber (1973), and Faber et al. (1977), can be found in Burstein et al. (1984); Faber et al. (1985) and in Brodie & Huchra (1990). This definition is continuously refined in newer works (see, for instance, Worthey et al. 1994 and Lick98 for more detailed description). Following Worthey et al. (1994), the raw value of the Mg_2 index, $(Mg_2)_{obs}$, in magnitudes is extracted as:

$$(\mathrm{Mg}_2)_{\mathrm{obs}} = -2.5\ \log \left[\left(\frac{1}{\lambda_2 - \lambda_1} \right) \int_{\lambda_1}^{\lambda_2} \frac{F_{\mathrm{I}\lambda}}{F_{\mathrm{C}\lambda}} \mathrm{d}\lambda \right], \quad (1)$$

where $F_{I\lambda}$ is the flux (in ergs s^{-1} cm^{-2} $Å^{-1}$) in the MgH and Mg *b* which is located at $\lambda\lambda 5154.125-5196.625$ Å. Here the local continuum, $F_{C\lambda}$, represents the run of flux defined by a stright line connecting the flux levels at midpoints of the corresponding blue and red "continuum" bandpasses (which are really pseudocontinua) at $\lambda\lambda 4895.125-4957.625$ Å and $\lambda\lambda 5301.125-5366.125$ Å. Throughout the paper, this definition is used.

A total of 41 publications, corresponding to 55 datasets were used to compile the catalogue. Here a dataset is a series of measurements sharing common characteristics: same observational setup, same reduction method.

The measurements of Mg_2 indices of Milky Way's globular clusters are also incorporated into the catalogue using the data of Burstein et al. (1984) and Lick98, because they are fundamental for the calibration of the age and metallicity of extragalactic stellar populations.

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* Tables 1, 3, and 4 are available in electronic form only at the CDS, Strasbourg, via anonymous ftp 130.79.128.5. Table 2 is available both in text and electronic form.

The extended set of Mg_2 observations of objects in Canada-France Redshift Survey (up to $z \approx 1$), published by Hammer et al. (1997), is not included in our catalogue since it concerns mostly distant galaxies for which the corrections into our standard system are uncertain.

The homogenisation of the Mg_2 indices is described in Sect. 2, and the catalogue is presented in Sect. 3. The completeness and some statistical properties of the sample of galaxies in this catalogue are discussed in Sect. 4.

This catalogue is maintained up-to-date in the database HYPERCAT, developed at the Observatoire de Lyon (http://www-obs.univ-lyon1.fr/~prugniel/cgi-bin/hyper-cat/). Check this URL for recent version.

2. The homogenisation of Mg_2 indices of galaxies

Three steps should be made to bring Mg_2 indices in a common, homogeneous system: (i) broadening correction (spectral resolution matching and velocity dispersion correction), (ii) aperture correction and (iii) dataset zero-point. The recipes for these corrections vary among the different authors and some of them give only corrected data.

We did not attempt here to standardize the measurements of globular clusters.

2.1. Broadening corrections

Both the spectral resolution of the observation and the intrinsic broadening of the spectral lines (velocity dispersion) affect the values of the Mg_2 measurements.

Corrections for these effect are small and often provided by the authors. In general the observations are preprocessed to match the Lick/IDS resolution and are usually normalized to 200 km s^{-1} (see Gonzales 1993, and JFK95). Recently Worthey & Ottaviani (1997) provided an elaborate mapping of the Lick resolution which is about 8.4 Å at 5300 Å thus corresponding to instrumental $\sigma = 200$ km s^{-1}. Hence, we did not make any further broadening correction than those already applied by the authors.

2.2. Aperture correction

Galaxies show radial (in general negative) gradients in the Mg_2 index. Thus, the derived central index depends on the size of the aperture used during the observations. Therefore Mg_2 index must be corrected for the effect of the increasing projected aperture size in the more distant galaxies which weakens their indices.

In their earlier works 7Sam have used the aperture corrected values of the observed index, $(Mg_2)_{obs}$, given by

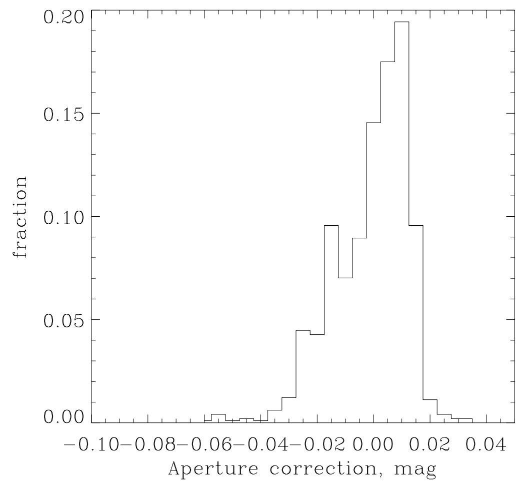

Fig. 1. The distribution of the aperture corrections of Mg_2 for 983 catalogued objects. The value $r_{norm} = 0.595\,h^{-1}$ kpc from JFK95 was used for normalization. Local Group objects and globular clusters are not included in the distribution

$$(Mg_2)_{corr} = (Mg_2)_{obs}\left[0.06\frac{V_{Group} - V_{Virgo}}{V_{Coma} - V_{Virgo}} + 0.94\right]. \quad (2)$$

The correction was calculated using the group velocity, V_{Group}, or heliocentric one if no group can be identified.

Perharps the better way to perform aperture corrections is proposed by JFK95:

$$(Mg_2)_{corr} = 0.04\log\frac{r_{ap}}{r_{norm}} + (Mg_2)_{obs}, \quad (3)$$

where r_{ap} is the physical radius sampled by that circular aperture from which one obtains the same $(Mg_2)_{obs}$ as through the actual aperture used. For a rectangular aperture of angular dimensions x and y radians, and a galaxy at distance d, the equivalent aperture is

$$r_{ap} \approx 1.025\left(\frac{xy}{\pi}\right)^{1/2} d, \quad (4)$$

where the factor 1.025 is introduced by JFK95 to provide a better matching to detailed galaxy models.

For the normalization JFK95 have used a physical radius $r_{norm} = 0.595\,h^{-1}$ kpc, which is equivalent to an angular diameter of 3.4 arcsec for the distance of Coma cluster. We adopted this normalisation which corresponds to a mean correction in the whole sample of -0.0008 ± 0.0133.

We have used distances based on flow-smoothed velocity which is defined as the velocity of the cosmologic flow associated with each galaxy ($H_0 = 70$ km s^{-1} Mpc^{-1} is adopted throughout this paper).

The flow-smoothed velocity is computed by averaging the velocity of galaxies found in the neigborhood of any galaxy. This grouping of galaxies is done iteratively.

At each step the size of the neighbouring region (in radius on the sky and in velocity interval) is computed from the distribution of the galaxies grouped at the previous step. The initial size goes from 0.5 Mpc for nearby galaxies to 3 Mpc for galaxies at the distance of 130 Mpc (9000 km s^{-1}), the initial velocity interval is 500 km s^{-1}. The velocities are taken from HYPERCAT (in turn updated from LEDA). The flow-smoothed velocity is then corrected for the deviations from the linear flow assuming the three-component velocity field model (Great Attractor, Virgocentric infall and Local Group Anomaly) described in Faber & Burstein (1988) and Burstein et al. (1989). Thus, for example, for the distance of Coma cluster the flow-smoothed velocity is 6903 ± 45 km s^{-1}.

For Local Group galaxies the distances are taken from the literature, in particular from van den Bergh (1989).

2.3. Dataset zero-point correction

Finally, even when much care has been taken to reduce all data to a common scale, systematic differences, at the level of ≈ 0.005, still persist. It should be mentioned here that many of the authors of the original papers attempted to calibrate their Mg_2 measurements to the Lick/IDS system (in general to consistency with the 7 *Samurai* data in some form), and therefore most of the offsets are fairly small. The intercomparison between datasets allow to detect and correct such zero-point differences.

We have determined these zero-points, together with a scaling of the error, in an iterative algorithm. At each step, for each galaxy, we have computed the error-weighted average Mg_2 (using the internal error) and we determined the mean and rms residual for each dataset after summing over all galaxies. The mean residual give the zero-point for the considered dataset, the rms is an estimate of the external error. The comparison between the external error and the mean internal error allows to re-scale the latter. The process is iterated after zeropointing and rescaling the internal error.

As a primary dataset at the beginning of the process the most comprehensive subsample from 7Sam is taken – the LICK dataset with 502 measurements for 272 galaxies. The algorithm used is in principle not stable and depends on the subset of objects in common between datasets. Hence, we interactively decided of the relevance of the corrections between each iteraction.

The corresponding values of the mean zero-point corrections, together with their errors and the mean rescaled internal errors, are given for each dataset in the list of the observational parameters (Table 2).

This standardisation could be done for 42 datasets totalizing 1060 galaxies. These datasets and galaxies are flagged in Table 2 and Table 4 respectively. The "standard homogeneous system" here is the union of all datasets which have been intercompared.

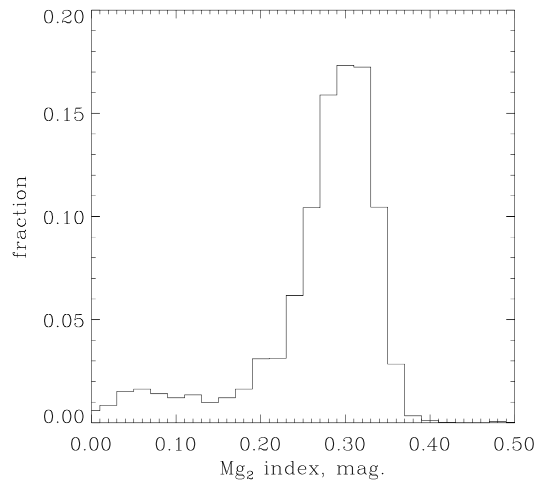

Fig. 2. The fractional distribution of "raw" Mg_2 index measurements included in the catalogue (3542 entries, bin size $0\overset{m}{.}02$). The secondary peak near $Mg_2 = 0.05$ corresponds to the globular clusters

3. Description of the catalogue

The catalogue consists of four separate files:

1. Compiled and aperture corrected measurements of Mg_2 indices (Table 1);
2. Observational parameters of each dataset (Table 2, available both in the text and in the electronic form at CDS);
3. Bibliography (Table 3);
4. Standard mean values of Mg_2 indices (Table 4).

3.1. The list of raw/compiled measurements of Mg_2 indices

The list contains the "raw" Mg_2-index in magnitudes, as given in the original publications. Observational setup and corrections possibly applied by the authors are described in the parameters file.

Each object is indexed by its normalized identifier. The galaxy identifiers follow the rule already used in Prugniel & Simien (1996 - hereafter PS96) and in Prugniel et al. (1998). Whenever it was possible, the identifier was chosen along the hierarhy NGC/IC, UGC/ESO, PGC. The original author's identifier is adopted when the cross-identification through NED or LEDA failed.

Beside the raw measurements we provide the aperture corrected and zero-pointed data (see Sect. 2).

Each measurement refers to a dataset which is expanded into its bibliographic reference in the bibliographic file and whose parameters are listed in the parameters file.

Table 2. Observational parameters

Dataset	$N^{a)}$	CDS/ADS reference code	$F_{ac}^{b)}$	$A_x^{c)}$	$A_y^{c)}$	Dataset zero-point correction$^{d)}$	Rescaled internal error$^{d)}$	$N_c^{d)}$	$F_h^{e)}$	$F_D^{f)}$	$F_{yn}^{g)}$
7Sam	403	1989ApJS...69..763F	1	4.00	4.00	0.002 ± 0.010	0.010	363	1	C	N
A1	66	1987ApJS...64..581D	0	2.00	7.00	−0.001 ± 0.010	0.010	40	1	C	N
A2	45	1987ApJS...64..581D	0	2.00	7.00	0.002 ± 0.014	0.010	39	1	C	N
BFGK84a	19	1984ApJ...287..586B	0	1.40	4.00	0	0	0	0	C	Y
BFGK84b	17	1984ApJ...287..586B	0	66.00	66.00	0.001 ± 0.004	0.014	17	1	C	Y
BT91	1	1991AJ....101..111B	0	2.00	4.00	0	0	0	0	P	Y
Ber+94	1	1994A&A...292..381B	0	2.50	2.50	0	0	0	0	P	N
Bur+88	32	1988ApJ...328..440B	0	1.40	4.00	−0.002 ± 0.012	0.014	31	1	C	N
C100a	28	1987ApJ...313...42D	0	16.00	16.00	0.002 ± 0.016	0.010	28	1	C	N
C100b	39	1987ApJ...313...42D	0	4.00	4.00	0.003 ± 0.006	0.010	28	1	C	N
CD94a	5	1994MNRAS.270..523C	0	1.50	3.00	−0.009 ± 0.009	0.011	4	1	P	Y
CD94b	2	1994MNRAS.270..743C	0	1.50	5.00	0.008 ± 0.005	0.005	2	1	P	Y
CDB-93	42	1993MNRAS.265..553C	0	1.50	3.00	−0.004 ± 0.010	0.009	33	1	P	Y
CGA95	9	1995MNRAS.277..502C	1	4.00	4.00	−0.003 ± 0.015	0.009	2	1	P	Y
CH88	9	1988AJ.....96..867C	0	2.00	4.00	−0.008 ± 0.015	0.012	9	1	P	N
DBD93	17	1993AJ....105.1737D	0	4.00	4.00	−0.003 ± 0.030	0.020	8	1	C	N
DFB91	136	1991ApJ...368...54D	1	4.00	4.00	0.003 ± 0.012	0.010	34	1	C	N
DSP93	13	1993MNRAS.262..650D	0	1.40	4.00	−0.002 ± 0.008	0.003	13	1	P	Y
Dav91	3	1991AJ....102..896D	0	3.00	1.60	−0.001 ± 0.002	0.005	3	1	P	Y
Dav92	11	1992AJ....103.1512D	0	3.00	3.00	−0.004 ± 0.007	0.003	11	1	P	Y
Dres84a	30	1984ApJ...281..512D	0	4.00	4.00	0.003 ± 0.007	0.007	30	1	C	N
Dres84b	23	1984ApJ...281..512D	0	16.00	16.00	0.005 ± 0.016	0.007	23	1	C	N
EG85	1	1985MNRAS.215p..37E	0	1.60	4.00	0	0	0	0	P	Y
FBD77	7	1977AJ.....82..941F	0	4.00	4.00	0.005 ± 0.009	0.010	6	1	C	Y
FFI96	22	1996ApJ...459..110F	0	2.00	4.00	0.004 ± 0.013	0.010	15	1	P	Y
GE87	15	1987IAUS..127..189G	0	2.50	4.00	0.009 ± 0.029	0.020	12	1	P	Y
GES90	33	1990MNRAS.245..217G	0	3.00	4.00	−0.002 ± 0.018	0.028	23	1	P	Y
GLCT92	83	1992MNRAS.257..187G	0	2.00	5.80	−0.002 ± 0.011	0.013	65	1	C	N
Gor+97	6	1997ApJ...481..L19G	0	2.00	4.00	0	0	0	0	C	Y
HCCJ94	1	1994AJ....107..195H	0	5.00	20.00	0	0	0	0	P	N
HP93	1	1993A&A...268..539H	0	2.50	3.00	0	0	0	0	P	Y
Huch+96	361	1996ApJS..102...29H	0	0.00	0.00	0.005 ± 0.040	0.028	33	1	C	Y
JFK95	182	1995MNRAS.276.1341J	2	3.40	3.40	0.002 ± 0.010	0.007	45	1	C	N
Jorg97	37	1997MNRAS.288..161J	2	3.40	3.40	0	0	0	0	C	Y
KPNO	28	1987ApJS...64..581D	0	2.30	4.20	0.005 ± 0.010	0.010	28	1	C	N
Kiss+98	20	1998AJ....115..105K	0	1.00	0.00	−0.007 ± 0.042	0.023	2	0	C	Y
LCO-2D	15	1987ApJS...64..581D	0	4.00	4.00	−0.002 ± 0.015	0.010	7	1	C	N
LCO-H2	6	1987ApJS...64..581D	0	4.00	4.00	0.014 ± 0.017	0.010	6	1	C	N
LCO-HI	194	1987ApJS...64..581D	0	4.00	4.00	0.004 ± 0.011	0.010	183	1	C	N
LCO-LO	82	1987ApJS...64..581D	0	2.00	4.00	0.000 ± 0.010	0.010	82	1	C	N
LGSC97	141	1997MNRAS.287..899L	0	3.00	3.30	−0.003 ± 0.014	0.017	90	1	C	N
LICK	502	1987ApJS...64..581D	0	1.50	4.00	0.000 ± 0.009	0.010	500	1	C	N
P200	30	1987ApJ...313...42D	0	2.00	4.00	0.001 ± 0.009	0.010	30	1	C	N
Pala+97	1	1997A&A...323..749P	0	1.40	0.70	0	0	0	0	P	Y
Pel89	9	1989egss.book.....P	0	1.50	1.50	0.001 ± 0.025	0.012	9	1	P	Y
S+97E93	103	1997MNRAS.291..461S	0	3.00	3.30	−0.003 ± 0.013	0.013	88	1	C	N
S+97T94	202	1997MNRAS.291..461S	0	3.00	3.30	−0.003 ± 0.009	0.010	149	1	C	N
SPD94	2	1994MNRAS.271...39S	0	1.30	1.30	0	0	0	0	P	Y
Schw96	1	1996AJ....111..109S	0	4.00	4.00	0	0	0	0	C	Y
TDFB81	24	1981MNRAS.196..381T	0	2.00	4.00	0.000 ± 0.014	0.010	24	1	C	N

Table 2. continued

Dataset	$N^{a)}$	CDS/ADS reference code	$F_{ac}^{b)}$	$A_x^{c)}$	$A_y^{c)}$	Dataset zero-point correction$^{d)}$	Rescaled internal error$^{e)}$	$N_c^{f)}$	$F_h^{g)}$	$F_D^{h)}$	$F_{yn}^{i)}$
Tr+98a	373	1997astro.ph.12258T	0	1.40	4.00	−0.002 ± 0.010	0.009	302	1	C	Y
Tr+98b	32	1997astro.ph.12258T	0	66.00	66.00	−0.002 ± 0.009	0.016	31	1	C	Y
WFG92a	45	1992ApJ...398...69W	0	1.40	4.00	−0.001 ± 0.009	0.010	45	1	C	Y
WFG92b	29	1992ApJ...398...69W	0	2.50	5.00	0.000 ± 0.012	0.010	28	1	C	Y
vdB+98	2	1998MNRAS.293..343V	0	0.26	0.26	0.000 ± 0.026	0.051	2	1	C	Y

Notes:

a) N is the number of measurements reported in the dataset. This number is not always equal to the number of observed objects because there are datasets which include multiple measurements of one object.

b) F_{ac} is a flag for aperture correction of the dataset:
 0 = no aperture correction;
 1 = aperture corrected to the Coma Cluster distance as it is described in 7Sam;
 2 = aperture corrected to the Coma Cluster distance as it is described in JFK95.

c) A_x and A_y are the aperture sizes $x \times y$ expressed in arcsec. For datasets with correction flag $F_{ac} = 2$ in both fields the aperture diameter 3.4 arcsec is given, which is equivalent to $r_{norm} = 0.595\,h^{-1}$ kpc for the distance of Coma cluster.

d) Mean zero-point (corrected catalogue − dataset average) and rms error on it. See Sect. 2.3 for details.

e) The correspodning rescaled internal error of the dataset. See Sect. 2.3 for details.

f) N_c is the number of galaxies used for comparison with the homogeneous system.

g) F_h is the homogenisation flag. When the corresponding dataset is corrected (zero-point) and rescaled to the homogeneous system of Mg_2 values listed in Table 4, 1 is used, otherwise 0. If $F_h = 0$, the values of the zero-point correction and rescaled error, as well as the number of galaxies N_c, are always 0.

h) F_D is the description flag of the observation – C is used for "central" measurement (2D field), and P for "radial profile" measurement.

i) F_{yn} is "Yes/No" flag, Y means other metallicity indices present in the reference, otherwise $F_{yn} = N$.

A flag on each Mg_2 index measurement is provided which describes its status (regular, discrepant, preliminary or republished, or a compilation value).

Only regular measurements are used to compute the mean standard values. Thus, the data from the 7 *Samurai* have been used as different datasets as published by Davies et al. (1987).

3.2. The list of the observational parameters

The description of each dataset is organised in a way which allow to make the corrections needed to bring given measurement in homogeneous system of values. These parameters describe the size of the slit, or the physical size of the aperture. The dataset's mean zero-point corrections determined by us as well as the corresponding re-scaled internal errors of the datasets are provided.

3.3. The list of the bibliography

The dataset acronyms are linked to the CDS/ADS BIBCODE (http://simbad.u-strasbg.fr/biblio/biblio.html) and to the full text of the reference.

3.4. The list of adopted Mg_2 *values*

For 1060 galaxies an 37 globular clusters we list in this file the mean value of the Mg_2 accompanied with the corrected flow-smoothed velocity we used for computing the aperture correction, and with a flag specifying if the value is given or not in the homogeneous system. The globular clusters do not belong to the homogeneous system. The definition of our standard homogeneous system is discussed in Sect. 2 above. This list is sorted by increasing of R.A.

4. Conclusion

We have compiled a catalogue of published absorption-line Mg_2 index measurements of galaxies and extragalactic globular clusters consisting of four tables available in electronic form only. In total, the catalogue contains 3541 measurements for 1491 galaxies and globular clusters from 55 datasets. Compiled raw data are aperture-corrected and transformed to our standard system.

The distribution of "raw" Mg_2 index values for the whole sample is shown in Fig. 2.

The comparison of homogenised Mg_2 indices with most of the datasets may be seen in Table 2.

Table 5. The overall statistical properties of the mean normalised Mg_2 index

Sub-sample	N	cz, km s^{-1}	Mg_2, mag	Density, Mpc^{-3}
nearby	231	1470	0.242 ± 0.073	0.002042
intermediate	378	3815	0.284 ± 0.041	0.000229
distant	391	7700	0.291 ± 0.036	0.000012

Notes: N is the number of galaxies in the sub-sample; cz is the mean corrected flow-smoothed velocity of the sample; Mg_2 is the mean value of the homogenised index for the sample given with its standard deviation.

For the sake of intercomparison we have divided the corrected Mg_2 data of Table 4 in three sub-samples according the Hubble distance:

- nearby objects ($\leq$ 30 Mpc),
- intermediate objects ($> 30 \div \leq 75$ Mpc), and
- distant objects ($> 75 \div \leq 200$ Mpc).

The most distant object in the catalogue is at 441 Mpc. Excluding 11 most distant objects, the rest of the galaxies lies within 200 Mpc.

Some overall statistical properties of these sub-samples are shown in Table 5. The mean Mg_2 decreases from one sub-sample to the next, reflecting the growing incompletness of the sample. Only the most luminous galaxies, with large Mg_2 are observed at large distances. This indicates the importance of the Malmquist-like bias in relations such as Luminosity vs. Mg_2.

As the catalogues described in PS96 and in Prugniel et al. (1998), this catalogue is connected to a hypertext interface to databases and catalogues, HYPERCAT, developped at the Observatoire de Lyon (http://www-obs.univ-lyon1.fr/hypercat/).

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