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An upgrade of the UoA nuclear electromagnetic moments database

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Abstract A web-based database of nuclear electromagnetic moments data has been created and hosted online at the University of Athens since 2012 [1]. In this work, we report on an update which has focused on syncing spectroscopic information, electric quadrupole and magnetic dipole moments with the ENSDF database [2] and literature values. A new feature is the incorporation of nuclear charge radii values obtained after 2015. Additionally, instructions of how to use the database, alongside with annotations and abbreviations, are presented.

Keywords database, charge radii, electric quadrupole moment, magnetic dipole moment

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INTRODUCTION

Nuclear moments play a vital role in our effort to better understand the nucleus. The Electric Quadrupole Moment (Q) is an observable that relates directly to the shape and size of the nucleus. On the other hand, the Magnetic Dipole Moment (μ) is a quantum operator that describes the nuclear magnetism in terms of the spin of the state in which the nucleus resides. Thus, measuring magnetic dipole moments can determine the wave function of a nuclear state in terms of the single-particle degrees of freedom. Despite the significance of the above values, the related experimental data are scattered throughout literature. As a result, the need to provide a user-friendly database that includes all the available experimental data is substantial.

THE DATABASE

The current version includes information for nearly every element (up to $Z=118$), with the most recent update having a cut-off date 2019-03-31. The main feature of the current effort is the addition of over 150 entries and 3 new experimental techniques of electric quadrupole and magnetic dipole moments. The update was based on searching published works found in the NSR database [3] and focused on pure experimental results. Data from the same database regarding rms charge radii ($\delta\langle r^2 \rangle$) published after 2017 were also included in the database for the first time. Additionally, level energies, half-lives and spin/parity values were synced with the ENSDF database.

Overall, the database now includes over 6300 levels with nuclear electromagnetic moments and charge radii. Elementary particle data are also available, adopting them directly from the Particle Data Group Evaluations [4]. Each entry is accompanied by the experimental method used to deduce it. A key feature of our database is the incorporation of the NSR keyword and DOI (digital object identifier) next to each experimental entry. Thus, all the available values for every energy level are gathered in the same group, with direct hyperlinks to the original citations, see also Fig. 1.

Isotope	Mass Excess [keV]	Energy [keV]	$t_{1/2}$	Spin/Parity	μ [nm]	Q [b]	R [fm]	Ref. Std	Method	NSR keyword	doi	Comment
^{19}Ne	1752.05 ± 0.16	0.	17.22 s	1/2 ⁺	-1.8846(8)			[^{21}Ne]	CFBLS	2005GE06	10.1103/PhysRevC.71.064319	

Figure 1. A typical example of information regarding a random isotope

DATABASE ARCHITECTURE

The main user interface of the database comprises of a search form (Fig. 2):

you may search for (Z), (A) or (Z and A)

Figure 2. The main user interface

By selecting an isotope based on its atomic number, all the available data for each of the known energy levels will be displayed.

< Bromine (Z=35) >
 wikipedia X-rays Atomic Data History of Br

⁷² Br	⁷³ Br	⁷⁴ Br	⁷⁵ Br	⁷⁶ Br	⁷⁷ Br	⁷⁸ Br	⁷⁹ Br	⁸⁰ Br	⁸¹ Br
⁸² Br	⁸⁴ Br								

Isotope	Mass Excess [keV]	Energy [keV]	t _{1/2}	Spin/Parity	μ [nm]	Q [b]	R [fm]	Ref. Std	Method	NSR keyword	doi	Comment
⁷⁹ Br	-76068.1 ± 1.3	0.	stable	3/2 ⁻	+2.106400(4)	+0.313(3) R	4.1629(21)	[² H]	NMR	1972BL07		
									R	2008PY02	10.1080/00268970802018367	
										2001BI17	10.1103/PhysRevA.64.052507	
									R	2004AL08	10.1103/PhysRevB.69.125101	
									AB, R	2000HA64	10.1103/PhysRevB.61.13588	
									AB, R	1998SE09	10.1103/PhysRevLett.80.5289	
										2013AN02	10.1016/j.adt.2011.12.006	
									TF	1994SP05	10.1016/0375-9474(94)90981-4	
									TF	1994SP05	10.1016/0375-9474(94)90981-4	
									TF	1994SP05	10.1016/0375-9474(94)90981-4	

Figure 3 Data for a specified atomic number

Searching based on the mass number will display information for a group of isobars.

< Iodine (Z=53) >
 wikipedia X-rays Atomic Data History of I

¹¹⁷ I	¹¹⁸ I	¹¹⁹ I	¹²⁰ I	¹²¹ I	¹²² I	¹²³ I	¹²⁴ I	¹²⁵ I	¹²⁶ I
¹²⁷ I	¹²⁸ I	¹²⁹ I	¹³⁰ I	¹³¹ I	¹³² I	¹³³ I	¹³⁵ I		

Isotope	Mass Excess [keV]	Energy [keV]	t _{1/2}	Spin/Parity	μ [nm]	Q [b]	R [fm]	Ref. Std	Method	NSR keyword	doi	Comment
¹²² I	-86080 ± 5	0.	3.63 m	1 ⁺	0.94(3)	+ve sign	4.759(59)	[131,132I]	NO/S	1986GR06	10.1016/0370-2693(86)90229-7	
									NO/S	1988AS06	10.1007/BFO2398330	

< Xenon (Z=54) >
 wikipedia X-rays Atomic Data History of Xe

¹¹⁶ Xe	¹¹⁷ Xe	¹¹⁸ Xe	¹¹⁹ Xe	¹²⁰ Xe	¹²¹ Xe	¹²² Xe	¹²³ Xe	¹²⁴ Xe	¹²⁵ Xe
¹²⁶ Xe	¹²⁷ Xe	¹²⁸ Xe	¹²⁹ Xe	¹³⁰ Xe	¹³¹ Xe	¹³² Xe	¹³³ Xe	¹³⁴ Xe	¹³⁵ Xe
¹³⁶ Xe	¹³⁷ Xe	¹³⁸ Xe	¹³⁹ Xe	¹⁴⁰ Xe	¹⁴¹ Xe	¹⁴² Xe	¹⁴³ Xe	¹⁴⁴ Xe	¹⁴⁶ Xe

Isotope	Mass Excess [keV]	Energy [keV]	t _{1/2}	Spin/Parity	μ [nm]	Q [b]	R [fm]	Ref. Std	Method	NSR keyword	doi	Comment
¹²² Xe	-85355 ± 11	0.	20.1 h	0 ⁺			4.759(59)			2013AN02	10.1016/j.adt.2011.12.006	

< Caesium (Z=55) >
 wikipedia X-rays Atomic Data History of Cs

¹¹⁸ Cs	¹¹⁹ Cs	¹²⁰ Cs	¹²¹ Cs	¹²² Cs	¹²³ Cs	¹²⁴ Cs	¹²⁵ Cs	¹²⁶ Cs	¹²⁷ Cs
¹²⁸ Cs	¹²⁹ Cs	¹³⁰ Cs	¹³¹ Cs	¹³² Cs	¹³³ Cs	¹³⁴ Cs	¹³⁵ Cs	¹³⁶ Cs	¹³⁷ Cs
¹³⁸ Cs	¹³⁹ Cs	¹⁴⁰ Cs	¹⁴¹ Cs	¹⁴² Cs	¹⁴³ Cs	¹⁴⁴ Cs	¹⁴⁵ Cs	¹⁴⁶ Cs	

Isotope	Mass Excess [keV]	Energy [keV]	t _{1/2}	Spin/Parity	μ [nm]	Q [b]	R [fm]	Ref. Std	Method	NSR keyword	doi	Comment
¹²² Cs	-78140 ± 30	0.	21.18 s	1 ⁺	-0.1333(9)	-0.179(10) R	4.7773(70)	[¹³³ Cs]	ABLS	1981TH06	10.1016/0375-9474(81)90274-8	
									AB	1977EK02	10.1103/0375-9474(77)90363-3	
										2013STZZ		
									ABLS	1981TH06	10.1016/0375-9474(81)90274-8	
										2013AN02	10.1016/j.adt.2011.12.006	
									ABLS	1981TH06	10.1016/0375-9474(81)90274-8	
										2013STZZ		
									ABLS	1981TH06	10.1016/0375-9474(81)90274-8	
										2013STZZ		
										ABLS	1981TH06	10.1016/0375-9474(81)90274-8

Figure 4. Data for a group of isobars with the same mass number

Alternatively, the user can select to use either the periodic table or the Z-helix, which provide access to the same results.

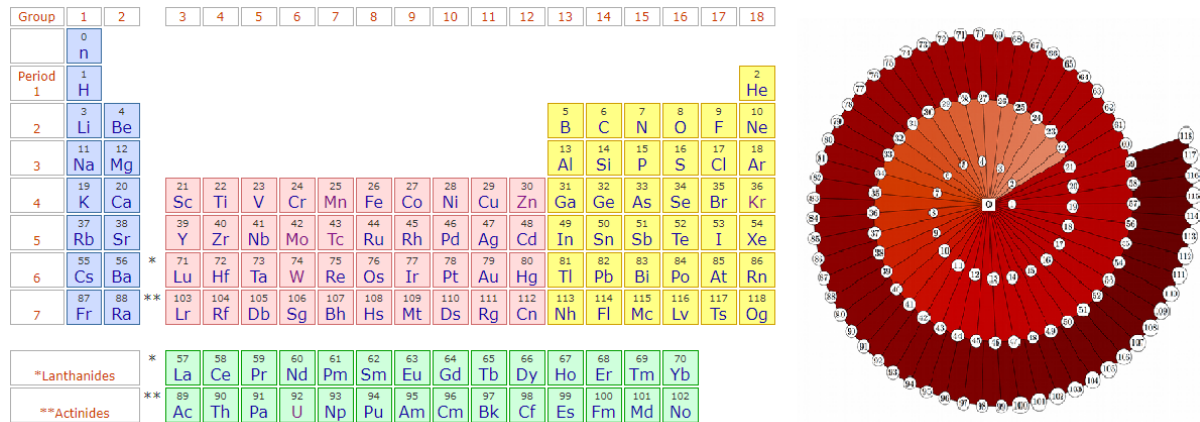


Figure 5 The periodic table (left) and the Z-helix (right)

The database is accompanied by a blog, in which the user can view updates and recommended citations, alongside with a help option including information for the experimental deduction methods, how to use the database and annotations. The option to directly submit new or re-evaluated data is, additionally, available.

CONCLUSIONS AND FUTURE WORK

Collectively, the current upgrade offers the most up-to-date experimentally deduced data. Future work will focus on more systematic updates concerning the mentioned databases, as well as syncing data with older tabulations, such as those by Fuller [5] and Raghavan [6], which have been left out of recent evaluations, generating some discussion among experts. An effort will be placed on providing plotting capabilities of systematics, as well as, on the design of an easy-to-use mobile app.

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