Searching harmonics in nuclei gyromagnetic ratios. Startling emergence of scaling, pseudo octaves, and the fine-structure constant from a seemingly random network.

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Abstract: A plot of the nuclei gyromagnetic ratios vs. corresponding mass numbers was intuitively fitted with classic damped sinusoids of the form [asin(bx+c)+d]exp(-kx) using the interactive QtiPlot software. The outcome was a 2D interlaced network from which unexpected scaling emerged. The sine waves frequencies in descending order were found to follow the intriguing correlation $b_N/2\pi=0.0100+0.137\exp(-N/1.306)$ with N=0,1,2... The amplitude value at 0.137 is interpreted as $10^{-3}/\alpha$ with α being the fine-structure constant. The scaling factor exp(1/1.306) which is ≈2.15 is discussed in relation to stretched octaves and probable connection to the golden ratio. The sinusoids equivalent energy range is found at E=7.29‒107 MeV. The asymptotic energy value at 7.29 is interpreted as $10^3\alpha$, from which a nucleon mean radius at ≈0.85 fm is deduced.

Introduction

Protons, neutrons and many nuclei carrying nuclear spin have associated gyromagnetic ratios (γ-ratios), generally expressed by $\gamma=\mu_Z/I\hbar$ in rad s^{-1} T^{-1}, where μ_Z is the z-component of the magnetic moment, I the spin quantum number of the particular nucleus, and ħ the reduced Planck constant. If an external magnetic field is applied, the γ-ratio gives rise to the nucleus precession called Larmor frequency around the field. The distribution of nuclei γ-ratios to their corresponding mass numbers appears as a random pattern. However, since γ-ratios are expression of frequency, an attempt was made to graphically connect γ-ratios through periodic oscillations, in order to possibly discover harmonics.

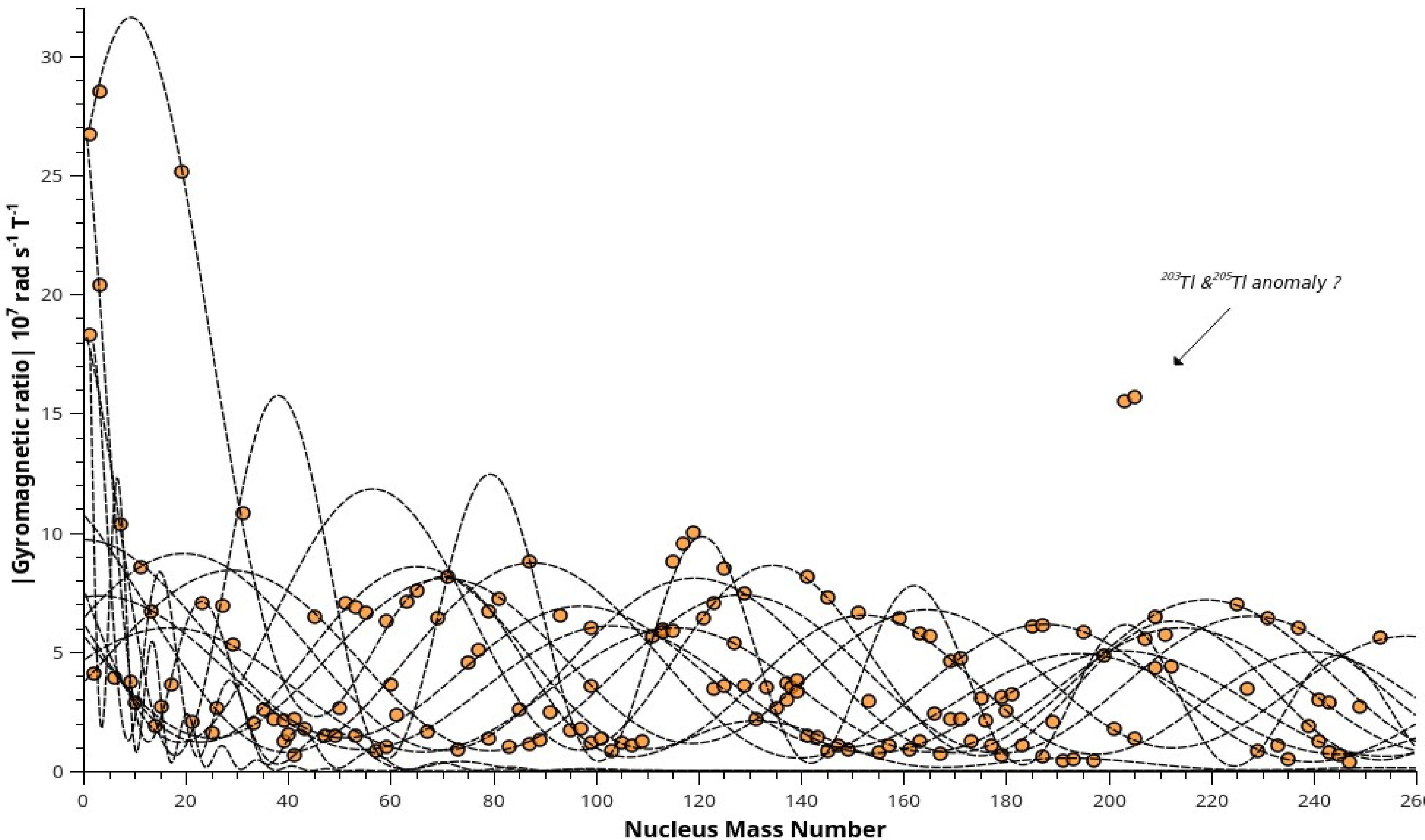
Searching harmonics in gyromagnetic ratios

The 160 nuclei γ-ratio values used in this study were published data from Bruker (Ref[1]). All graphing and data analysis were performed using the scientific QtiPlot software (Ref[2]). The fitting of damped sine waves was carried out intuitively and optimized using the interactive capabilities of the software. Damped sine waves of the form [asin(bx+c)+d]exp(-kx) were used throughout. It was quickly estimated that a number of 10-15 sinusoids were required to capture all nuclei. A number of 14 sinusoids were used in this study, and the result is depicted in Figure 1. At this level of N=14, the coefficient b has already reached the plateau of an apparent asymptotic limit at ~0.0628, which is interpreted as 2π/100. The following Table 1 summarizes the various coefficients found for the damped sinusoids.

Table 1: Coefficients found for the damped sinusoids [asin(bx+c)+d]exp(-kx)

	Coefficients										
Function	**a**	**b**	**c**	**d**	**k**	**Function**	**a**	**b**	**c**	**d**	**k**
F1	12.6	0.924	1.4	15.3	0.12	**F8**	3.9	0.067	3.05	5.35	0.0019
F2	9	0.46	0.7	11.1	0.058	**F9**	4.04	0.0647	1.44	5.7	0.0035
F3	12.8	0.249	1.6	15.3	0.0575	**F10**	2.6	0.0637	0.49	3.4	0.000
F4	9.43	0.152	1.99	10.16	0.0057	**F11**	3.9	0.0632	5.981	4.84	0.0013
F5	17.4	0.103	0.11	23.6	0.0222	**F12**	3.2	0.063	1.3	4.2	0.0019
F6	6.8	0.0805	3.2	8.1	0.0040	**F13**	4.2	0.063	6.581	5.14	0.0012
F7	4.6	0.072	3.07	5.9	0.0031	**F14**	5.5	0.0629	2.22	6.4	0.0035

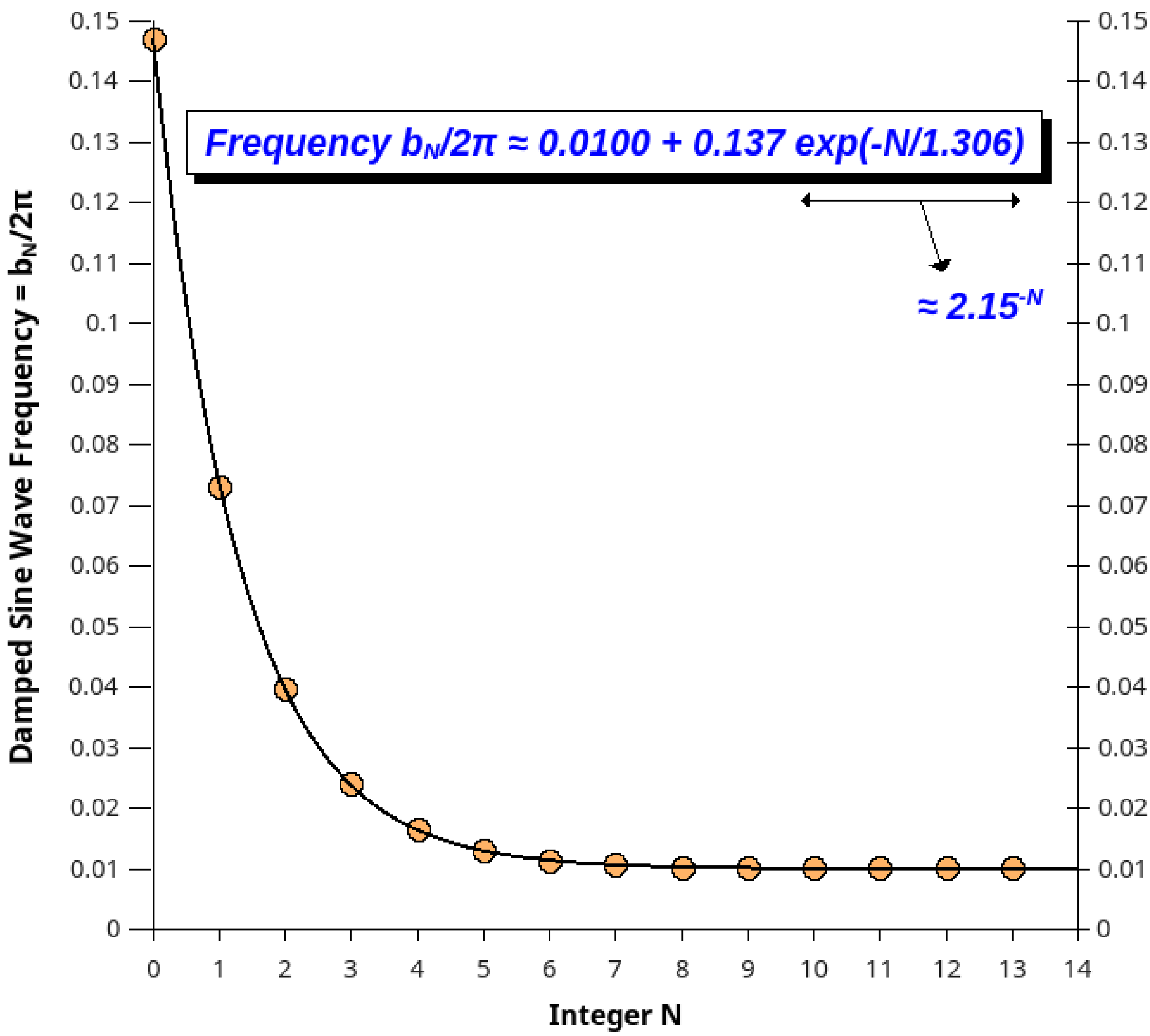
Figure 1: Searching harmonics in the gyromagnetic ratios. Intuitive fitting of damped sine waves to gyromagnetic ratios (absolute values) vs. nuclei mass numbers, using interactive QtiPlot software.



The damped sinusoids in Figure 1 create a 2D interlaced network, with amplitudes declining from light to heavier elements. It was realized that two sinusoids can obviously originate from the proton, and two others from the neutron. Figure 1 seems to indicate that Thallium isotopes 203 and 205 are excluded from the network, indicative of possible magnetic moments anomaly. In fact, hyperfine anomaly have been reported in the literature for those nuclei (Ref[3]).

The sine waves frequencies $b/2\pi$ in descending order, (expressed in number of periods per mass number unit), were subsequently plot against ascending integer values starting with N=0. An intriguing correlation was revealed in Figure 2.

Figure 2: Plot of discrete sinusoid frequencies $b_N/2\pi$ (expressed in number of periods per mass number unit) in descending order vs. integer values N=0,1,2....



Asymptotic limit, fine-structure constant, and pseudo octaves

The correlation revealed in Figure 2 exhibits intriguing coefficients. First of all the graph asymptotic limit value appears around $b/2\pi=0.01005\pm0.00005$, which corresponds to a coefficient b (equiv to angular frequency) almost exactly $2\pi/100$. Further, the ratio of the highest frequency value (0.147) to the asymptotic limit (0.01) gives 14.7. This value is generally referred as the coupling constant of the strong force in gravitational model of strong interaction (Ref[4]).

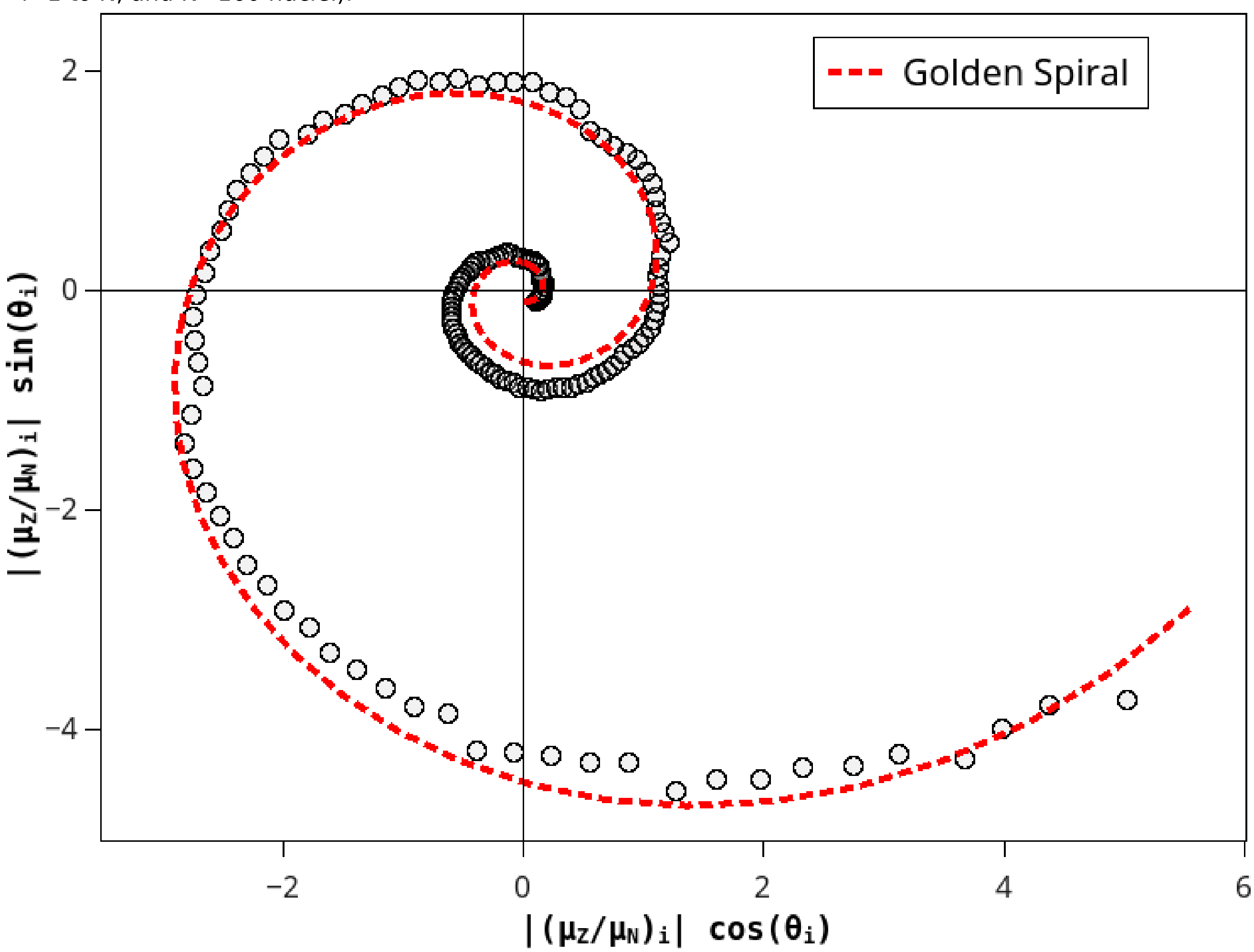
The amplitude value of 0.137 is interpreted as $10^{-3}/\alpha$ with α being the fine-structure constant. However, the precision provided by the graph for this coefficient is no greater than the third decimal, and as a result, the identity of the fine structure constant in the equation cannot be definitely established from the least square regression line.

The scaling factor $e^{1/1.306}$ which corresponds to 2.15 (± 0.01) indicates that each frequency of the network is 2.15 times higher (or lower) than the neighboring frequency. This is the principle of calculating octaves, for which a factor of exactly 2.0 is traditionally used. As such, the network in Figure 1 can be regarded as composed of periodic oscillations whose frequencies are stretched octaves, or enlarged octaves.

Could the scaling factor 2.15 be related to the golden ratio ?

The scaling factor 2.15 ($\sim e^{1/1.306}$) was determined graphically, and consequently without derivation indicative of it's true origin. However, the exponent 1/1.306 has been reported in the study of some networks such as Ref[5], for which the mean-square displacement of random walks through the network was found to be $<r^2>=t^{2/1.306}$. In this formula, 1.306 was the diffusion exponent equal to $2\text{-}\log_2\varphi$, with φ being the golden ratio. A number of other combinations involving φ can also lead to the value 1.306, for instance $1/\log(\varphi^{5/\pi})$, $1/\log(\sqrt{2}+\varphi^{-2/\pi})$ or $1/\log(\alpha^2 10^4+\varphi)$. Likewise, the presence of the golden ratio would not be of a great surprise since the nuclei magnetic moment, giving rise to the gyromagnetic ratio, appears somehow linked to the golden ratio, as shown in Figure 3.

Figure 3: A close link of the nuclei magnetic moments to the golden spiral. Nuclei magnetic moments μ_Z/μ_N in absolute values and ascending order are spatially spread over 3.8π radian and plot in polar coordinates (μ_Z is the z-component of nuclear magnetic moment in units of the nuclear magneton μ_N). The angle θ_i=i*3.8π/N, i=1 to N, and N=160 nuclei).



Oscillations equivalent energy

The period of the sine waves given by T= 2π/b fluctuates within the following limits T≈ [6.8‒100] expressed in nucleon unit. By considering nucleons as spherical units of approx radius ~ 0.85 fm and diameter ~ 1.7 fm, it becomes possible to determine the wavelength corresponding to the period T, by multiplying T*1.7 fm. Therefore, the calculated wavelength range sets at λ≈[11.6‒170] fm, which translates into equivalent energy (E=hc/λ) to E=[7.29‒107] MeV. This energy range fits gamma-rays energy domain.

The asymptotic low energy limit of 7.29 MeV is comparable to the high energy bound of gamma emission typically associated with gamma nuclear decay (4-5 MeV).

Coincidentally, it also appears that this low energy value of 7.29 MeV corresponding to the frequency asymptotic limit b/2π=0.0100 (Figure 2) is a very close to $10^3\alpha$ MeV, α being the fine-structure constant. If that correspondence is not fortuitous, then the nucleon mean value of 0.85 fm used in the calculation seems a very realistic approximation. This value turns out to fit well within reported muonic measurements of the proton charge radius.

Conclusion

The puzzling emergence of scaling and order from the gyromagnetic ratios network in Figure 1 may be indicative of non-random nuclei magnetic moments distribution, in terms of “relations” to each other. As the matter of fact, the periodic oscillations constructed in Figure 1 could be seen as common (resonant) frequencies shared by sets of particular nuclei, with some nuclei engaged in more than one frequency. It should be stressed that the designation “resonance” utilized here could be of a different nature than the definition generally used for instance in nucleosynthesis.

The three coefficients obtained from the correlation in Figure 2 arouse curiosity, in particular the emergence of the enigmatic fine-structure constant, or the probable interference of the ubiquitous golden ratio. Likewise, the asymptotic value of the angular frequency b appearing at almost exactly 2π/100 is mysterious.

The frequency scaling factor of 2.15, interpreted as stretched or enlarged octave, and associated with gamma-ray energy levels is noteworthy. As it turns out, the cosmic gamma-ray background radiation (CGB) is one of the most fundamental observables in the gamma-ray band. The origin of the CGB has been an intriguing mystery since it's discovery by the SAS-2 satellite more than forty years ago (Ref[6]), despite new discoveries in recent years. Moreover, the mass of many particles including protons and neutrons composing visible matter fall into the gamma-ray energy range, and their long lasting existence and stability inside nuclei is enigmatic, in light of purely entropic considerations. As speculative as it may be, the energy contained in the cosmic gamma-rays could be the answer by nature for countering the second law of thermodynamics and preventing the short term decay of “stable” nuclei, thus legitimating what is called the strong force. Otherwise, the Boltzmann paradox could have prevailed.

The true significance of those findings is still unclear. The question of the existence of a cosmic clock featuring pseudo octaves in the gamma-ray domain remains.

References

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