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Classical mechanics analysis of the atomic wave and particulate forms

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ABSTRACT
Physical properties of the atom's intrinsic electromagnetic (e-m) harmonic oscillation are analyzed with SHM formalism. The results would suggest that light does not travel in the sense of rectilinear motion, it is an oscillating e-m loop of cosmic proportions and rotates as it radiates. It is re-affirmed that the atom exists simultaneously as wave and as particle, each characterized by specific physical properties and further revealed that: (i) waveforms of the chemical elements bind together into a perfect superfluid to constitute space (i.e., the "vacuum") as such physical properties of the vacuum are summations of properties of each element's waveform and comprise values of atomic radius, density, angular speed, centripetal force and modulus analogous to corresponding values of the visible elements; (ii) waveform densities add up to 2.608889474 x 10^{-36} kg/m^3; the value confirms existence of the long speculated vacuum energy; given the density, cosmological constant evaluates at Λ = 7.2955513855 x 10^{-52} m^{-2} confirming the observed value ~$10^{-52}m^{-2}$; (iii) the combined λ values of the wave and particulate forms gives rise to the e-m spectrum; (iv) radioactivity results from changes in tensile properties of the atom as atomic number increases, it is an exclusive phenomenon of the microcosmic atom, the visible macrocosmic particulate form plays no role whatsoever;(v) the results would suggest that atomic wave and particulate forms are identifiable with bosons and fermions respectively.

Keywords: Atomic Classical (Newtonian) Mechanics; Physical Properties; Simple harmonic motion; Radioactivity.

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I. INTRODUCTION

As presently constituted quantum physics rests on a speculative foundation hence we have now reached the point where advances in empiricism throw up realities that question the basis of that foundation. Our investigation of the subject suggests the necessity for a major paradigm shift that would address the unknown from the well known and we submit that despite phenomenal advances in technology and the underlying theoretical framework, with regard to the atom, physics has only one positively known - relative atomic mass m_r. Knowledge of the phenomenon that specifies values of this known should lead to a better understanding of other properties of the atom. Since Lorentz's seminal treatises [1], there have been several theoretical constructs for atomic mass; notably, de Broglie's re-interpretation [2] of the combined energy equations of Planck [3] and Einstein [4]. In our context the equation,

$$h\vartheta = mc^2, \quad (1)$$

assigns to each element specific e-m field ϑ and inertial mass m values. We were unable to find a reported attempt to evaluate m with eq. (1) and recognize that physics is yet to provide relevant values of ϑ. Although tentative values were published in 1957 [5], they have been ignored on seemingly justifiable grounds. We decided nonetheless to attempt evaluating m_r by first substituting the published ϑ values in (1) to obtain each element's absolute atomic mass m_{abs} (or m_w) value. The result was completely unexpected, in contrast with an approx. linear trend observed for empirical m_r, values of m_w increase exponentially with an increase in atomic number Z. In order to reproduce m_r from m_w values, it became necessary to conceive of three frames of reference for the atom. The simplest empirical model (tagged "Lever System Cosmological Model") that successfully describes this structure yields striking results that perfectly corroborate values of some established physical constants but differ markedly in perception of the causalities. It turned out, for instance, that the atom exists simultaneously in the micro- and macrocosms in three mutually orthogonal domains. In the macrocosm it exists only as wave-embedded particles; however, the microcosm comprises both wave and wave-embedded particles. The wave is characterized by absolute not relative atomic mass values, it is the only form for which eq. (1) is strictly applicable. These results have been reported [6,7]; here, we present results of analysis of the atom's wave – particle dual existence within the context of its physical properties.

II. EVALUATION OF PHYSICAL PROPERTIES OF THE ATOM

If, as has been proposed [5,8,9] and demonstrated [6,7] the atom is essentially an e-m field, it should be describable with established formalisms of simple harmonic motion (SHM) and the following quantitative expressions would apply:

i. Radius, $r = \lambda/2 = c/2\vartheta$ (2)

where the wavelength $\lambda = c/\vartheta$, and values of ϑ and c depend on the atom's specific wave or particulate form.

ii. Density, $\rho = m/v = m/(4\pi r^3/3) = 6m\vartheta^3/\pi c^3$, (3)

where values of mass m and volume v depend also on the atom's specific form.

iii. Angular speed, $\omega = 2\pi\vartheta$, (4)

iv. Centripetal Force, $F = m\omega^2 r = 8\pi^2 m\vartheta^3/c$, (5)

v. Elastic Modulus, $\epsilon = m\omega^2 = 4\pi^2 m\vartheta^2$, (6)

vi. Longitudinal Stress, $\sigma = F/\pi r^2 = 8\pi m\vartheta^3/c$ (7)

vii. Strain rate, $\tau = \sigma/\epsilon = 2\vartheta/\pi c = \omega/\pi^2 c$ (8)

Results of these calculations are presented.

III. RESULTS AND DISCUSSION

Values of the physical properties calculated with eqs. (2) to (8) are summarized in Table 1 for the chemical elements, the details are illustrated in Figs. 1 to 7. Table 1 contains three sections that present properties of the various forms of the atom: (1) Absolute Ref. Frame's microcosmic waveform U^*_{abs}; (2) Visible Ref. Frame's macrocosmic particulate form U^o_r; and (3) Invisible relative component of the Absolute ref. frame U^*_r plus Invisible Analogue U'_r of the Visible Frame, both having microcosmic particulate matter. The ref. frames are co-existent, orthogonal, interactive and freely exchange inertial mass and energy; they are defined by the same set of chemical elements undergoing the same periodicity, as a result we have tagged them parallel universes [6,7]. The results show clearly that each form is characterized by its specific de Broglie wavelength defined by eq. (1). The waveform's absolute atomic mass m^*_w (or m^*_{abs}) varies from 7.37 x 10^{-51} to 4.75 x 10^{-41} kg/atom for electron e to americium Am respectively. The value 7.37 x 10^{-51} kg/atom compares reasonably with 10^{-53} kg/atom postulated by de Broglie [2] and ~10^{-54} kg/atom speculated recently as experimental limit for the photon [10]. For the visible universe U^o_r, molar mass m^o_r values vary across the periodicity from 9.77 x 10^{-7} to 0.234 kg/mol for Ab to Am respectively [6,7]. With this brief background we discuss the present results.

A. Radius of the non-bonded neutral isolated atom

Atomic waveform's radius r_w varies from 1.4990 x 10^8 to 2.3267 x 10^{-2} m for Russell's first element "alberton" Ab to americium Am respectively, Table 1. Corresponding values for the visible particulate molar unit r^o_p are 9.1312 x 10^{-15} to 3.6696 x 10^{-20} m respectively. Likewise, corresponding values for the microcosmic particulate form r^*_p (or r'_p) are 1.8262 x 10^{-14} to 2.8349 x 10^{-24} m for Ab to Am respectively. Note that these values refer to the non-bonded neutral isolated individual atom completely free of influence of a field other than its own. This form of the atom was hitherto inaccessible to physics and this is possibly the first time its physical properties are being reported. The value $r_{w(Ab)}$ = 1.4990 x 10^8 m is of course $\lambda/2$, where $\lambda = c/\vartheta$, ϑ = 1.0 Hz [6,7] and c is the transverse vacuum radiation; r_w therefore positively identifies Ab's waveform with the long wave end of the e-m spectrum. Observe also that the visible atom's particulate Ab's radius $r_{p(Ab)}$ = 9.1312 x 10^{-15} m compares well with the "classical electron radius" (CER) r_e = 2.8179 x 10^{-15} m despite a wide margin between the electron mass m_e value obtained here 7.37 x 10^{-51} kg and literature value 9.11 x 10^{-30} kg. Thus, $r_{p(Ab)}$ is positively identified here with the electron e re-affirming that Russell's Ab is indeed the electron. In previous reports we also identified Ab with e on the basis of similarity of relative atomic mass values [6] and correspondence between values of h and e's internal energy [7]. Ab is first element of Russell's periodicity, its positive identification with e would support our earlier submission [6] that e is a full-fledged element on its own merit and is indeed the first member of the chemical periodicity; there is a large volume of literature to buttress this position [11-14]. For the neutral isolated atom, r value decreases with an increase in atomic number Z notably, the same trend is observed for the wave and particulate forms regardless of cosmic domain Fig. 1. The literature presents the contrary, i.e., empirical r values increase generally with an increase in Z value [15-17]. We submit that effects responsible for observed increase in r value along the periodicity such as shielding (18) arise from the chemical (i.e., e-m [1]) environment and are not intrinsic nature of the isolated atom. For instance, we find four orders of magnitude difference between literature's covalent H-H radius of molar hydrogen r_{H-H} = 2.5 x 10^{-11} m [15,16] as against the present value r_H = 9.1 x 10^{-15} m for the isolated non-bonded H-atom.

It is not unlikely that if r values were not thus enlarged significantly, tangible matter and gravity would have been absolutely intractable. The electron's waveform radius $r_{e(w)}$ = 1.4990 x 10^8 m is significant, cosmological dimensions are measured in units of the light year, however, in the SHM context light does not translocate, it is an e-m wave oscillating within the cosmic envelope with $\lambda = c/\vartheta =$ 2.99792458 x 10^8 m (ϑ_{Ab} = 1.0 Hz [5]).

TABLE 1: A summary of some physical properties of the elements

Atom	At. Radius r/m	At. Density ρ/kg m^{-3}	Angular Speed ω/rad s^{-2}	Centripetal Force F/N	Elastic Modulus ϵ/Pa	Longtd. Stress σ/Pa	Strain Value τ
		Absolute Ref. Frame - microcosmic waveforms					
Ab(e)	1.4990E+08	5.2258E-76	4.1917E-08	4.3628E-41	2.9105E-49	6.1806E-58	2.1235E-09
H	7.3192E+04	9.1933E-63	1.7581E-01	1.8299E-34	2.5001E-39	1.0873E-44	4.3490E-06
C	9.1489E+03	3.7656E-59	1.1252E+01	1.1711E-32	1.2801E-36	4.4536E-41	3.4792E-05
Si	1.1436E+03	1.5424E-55	7.2013E+02	7.4952E-31	6.5540E-34	1.8242E-37	2.7834E-04
Fe	7.1476E+01	1.0108E-50	1.8435E+05	1.9188E-28	2.6845E-30	1.1955E-32	4.4534E-03
Br	3.8121E+01	1.2493E-49	6.4811E+05	6.7457E-28	1.7696E-29	1.4776E-31	8.3501E-03
Ba	1.1168E+00	1.6959E-43	7.5511E+08	7.8593E-25	7.0373E-25	2.0057E-25	2.8502E-01
Ta	2.5071E-01	6.6774E-41	1.4984E+10	1.5595E-23	6.2203E-23	7.8974E-23	1.2696E+00
Rn	1.3960E-01	6.9463E-40	4.8327E+10	5.0300E-23	3.6031E-22	8.2155E-22	2.2801E+00
U	3.1023E-02	2.8484E-37	9.7862E+11	1.0186E-21	3.2833E-20	3.3689E-19	1.0261E+01
Am	2.3267E-02	9.0024E-37	1.7398E+12	1.8108E-21	7.7827E-20	1.0647E-18	1.3681E+01
		Visible Ref. Frame - macrocosmic particulate forms					
Ab(e)	9.1312E-15	3.0622E+35	1.3999E+15	1.4570E-18	1.5957E-04	5.5625E+09	3.4860E+13
H	4.4586E-18	5.3871E+48	5.8716E+21	6.1113E-12	1.3707E+06	9.7857E+22	7.1393E+16
C	7.4248E-19	7.0050E+51	2.1173E+23	2.2037E-10	2.9681E+08	1.2725E+26	4.2871E+17
Si	3.1745E-19	2.0962E+53	1.1582E+24	1.2055E-09	3.7975E+09	3.8078E+27	1.0027E+18
Fe	1.5966E-19	3.2759E+54	4.5787E+24	4.7656E-09	2.9848E+10	5.9507E+28	1.9936E+18
Br	1.1160E-19	1.3722E+55	9.3711E+24	9.7537E-09	8.7395E+10	2.4926E+29	2.8521E+18
Ba	6.4932E-20	1.1976E+56	2.7684E+25	2.8814E-08	4.4376E+11	2.1754E+30	4.9022E+18
Ta	4.9280E-20	3.6097E+56	4.8063E+25	5.0025E-08	1.0151E+12	6.5570E+30	6.4593E+18
Rn	4.0167E-20	8.1780E+56	7.2344E+25	7.5297E-08	1.8746E+12	1.4855E+31	7.9246E+18
U	3.7462E-20	1.0808E+57	8.3169E+25	8.6564E-08	2.3107E+12	1.9634E+31	8.4968E+18
Am	3.6696E-20	1.1740E+57	8.6678E+25	9.0217E-08	2.4585E+12	2.1325E+31	8.6742E+18
		Abs. Ref. Frame, Relative Compont.- microcosmic particulate forms					
Ab(e)	1.8262E-14	1.9139E+34	3.4998E+14	3.6426E-19	1.9946E-05	3.4766E+08	1.7430E+13
H	8.9171E-18	3.3669E+47	1.4679E+21	1.5278E-12	1.7134E+05	6.1161E+21	3.5696E+16
C	2.2237E-18	8.7058E+49	2.3604E+22	2.4568E-11	1.1048E+07	1.5814E+24	1.4314E+17
Si	2.4832E-19	5.5988E+53	1.8929E+24	1.9702E-09	7.9340E+09	1.0170E+28	1.2819E+18
Fe	9.2105E-21	2.9580E+59	1.3759E+27	1.4321E-06	1.5548E+14	5.3733E+33	3.4559E+19
Br	4.8460E-21	3.8601E+60	4.9703E+27	5.1732E-06	1.0675E+15	7.0119E+34	6.5685E+19
Ba	1.3635E-22	6.1590E+66	6.2782E+30	6.5345E-03	4.7924E+19	1.1188E+41	2.3345E+21
Ta	3.0564E-23	2.4394E+69	1.2495E+32	1.3005E-01	4.2549E+21	4.4313E+43	1.0414E+22
Rn	1.7015E-23	2.5397E+70	4.0315E+32	4.1961E-01	2.4661E+22	4.6133E+44	1.8707E+22
U	3.7800E-24	1.0428E+73	8.1691E+33	8.5026E+00	2.2494E+24	1.8942E+47	8.4210E+22
Am	2.8349E-24	3.2960E+73	1.4524E+34	1.5116E+01	5.3323E+24	5.9872E+47	1.1228E+23

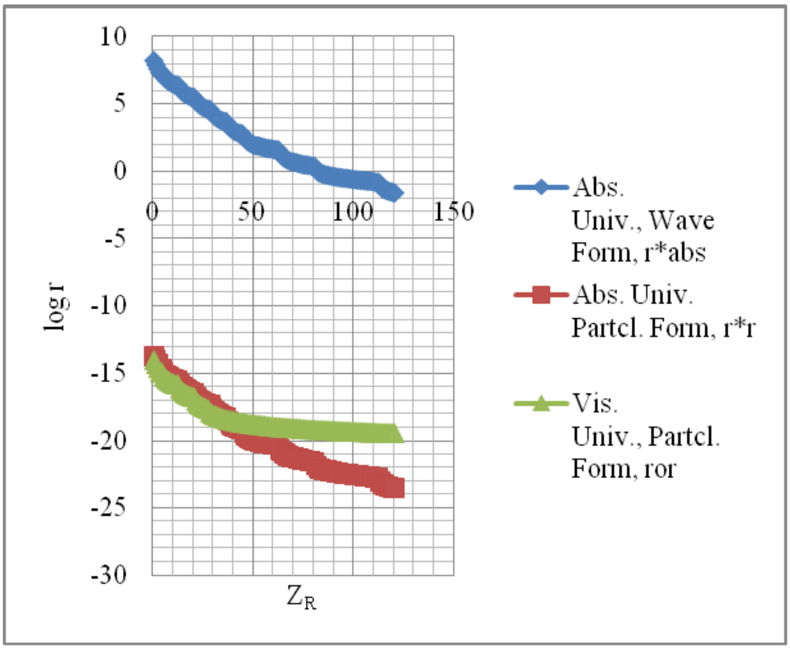

Fig. 1 Plot of atomic radius log r vs. atomic no. Z_R

The value of $r_{e(w)}$ implies therefore that distances covered by light actually represent accessible extents of e's waveform envelopes. Thus, although it has non-zero mass, the photonic envelope can and does oscillate at angular speeds greater than light without violating quantum restrictions [19] and we find in Table 1 speeds in excess of 10^{10} rads/s. Plots of r vs. Z are parabolic (Fig. 1), attempts to 'linearize' these curves revealed that variations of all atomic physical parameters with Z are strictly non-linear. For instance, a plot of $\sqrt{\vartheta}$ vs. Z yields the expression $\vartheta = \{6.68(Z - 6.0524)\}^2$ with $R^2 = 0.98$, i.e., the graph is a best fit not the perfect straight line obtained by Thomson [20] suggesting that the present investigation addresses a different level of the atom's e-m radiation. The log-log correlation illustrated in Fig. 2 proved quite invaluable, the procedure produced a resourceful range of linear correlations that would take quite a while to fully investigate.

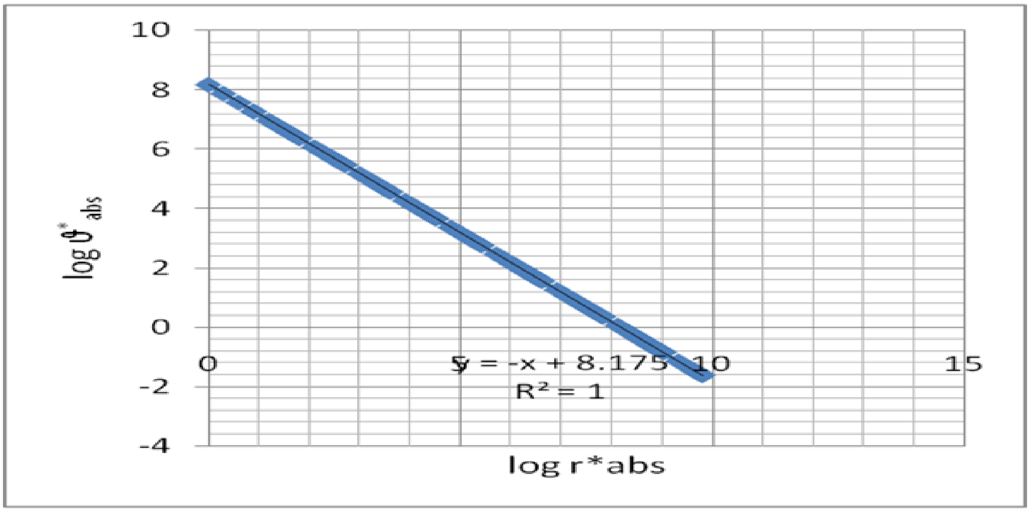

Fig. 2: Plot of log ϑ^*_{abs} vs. log r^*_{abs} – waveform

For instance, Fig. 2 gives the following correlation of ϑ with r:

$$\vartheta = A_1/r \quad (9)$$

where A_1 = 1.4962235656 x 10^8 for waveform and 1.862087173 x 10^{-14} m for particulate atom; these values are easily recognizable as graphical estimates of $r_{e(w)}$ and $r^*_{e(p)}$ respectively. Notably, the molar value $r^*_{e(p)}$ = 1.86209 x 10^{-14} m corroborates our earlier submission that it refers to the cosmic microwave background (CMB) [6,7]; furthermore, it is shown in Table 2 that the combined radii of the wave and particulate forms gives rise to the e-m spectrum.

TABLE 2: Comparison of atomic ϑ and λ values with e-m spectrum

Russ. Period	Russell's Element	Russ. Atm. No. Z_R	Atomic e-m Freq. $\vartheta_{At.}$/Hz	Atomic Wave length $\lambda_{At.}$/m	Literature e-m Spec. $\vartheta_{e\text{-}m}$/Hz	Literature e-m Spec. $\lambda_{e\text{-}m}$/m	Source /Use
		Microcosmic Atomic Waveform					
1	Ab = e	1	1.0	2.9979E8	1	10^8	Long
2	Bl –En	2 – 6	2 -16	1.5 - 1.9E8	2 -10	10^8 - 10^7	Waves
3	Ey – Vt	7 – 15	24 – 192	1.2E7 - 1.6E6	10 - 10^2	10^7 - 10^6	Audio
4	Ou – H	16 – 24	256 -2048	1.2E6 - 1.6E5	10^2 -10^3	10^6 -10^5	Waves
5	L – O	25 -34	2.5E3 - 2.4E4	9.8 - 1.0E4	10^3 -10^4	10^5 - 10^4	
6	F – Ar	35 – 44	2.9E4 - 2.6E5	9.1 - 1.1E3	10^4 - 10^5	10^4 -10^3	Radio
7	K – Cu	45 – 55	2.6E5 - 2.6E6	572- 102	10^5 -10^6	10^3 - 10^2	
8	Zn – Mo	56 -68	2.9E6 - 2.5E7	95.3 - 10.2	10^6 -10^7	10^2 -10	Waves
9	Tc – Pr	69 -85	2.9E7 - 2.5E8	8.93 - 1.08	10^7 - 10^8	10 - 10^{-1}	Micro-
10	Nd – Fr	86 – 113	2.8E8 - 1.1E9	0.984 - 0.140	10^8 -10^9	1o^{-1} - 10^{-2}	
1	Ra – Am	114 -121	2.2 - 6 44E9	0.093 - 0.047	10^9 - 10^{10}	10^{-2} - 10^{-3}	Waves
		Micro/Macrocosmic Atomic Particulate Form			10^{10} -10^{22}	10^{-4} - 10^{-13}	IR,V,UV,X- & γ- Rays
1	e – Bl	1 – 2	1.02 - 2.03	3.7 - 1.8E-14	10^{22} - 10^{23}	10^{-14} - 10^{-15}	Gamma
2	Bs – Ah	3 – 8	4.07 -32.55	9.1E-14 - 1.1E-15	10^{24} - 10^{25}	10^{-15} - 10^{-16}	Rays
3	Bd – Tr	9 – 17	40.69 - 325.5	9.1E-15 - 1.1E-16	10^{25} - 10^{26}	10^{-16} - 10^{-17}	α-
4	Bz – Ng	18 -27	3.9E2 - 3.7E3	9.5-16 - 1.0E-17	10^{26} - 10^{27}	10^{-17} - 10^{-18}	
5	He – Na	28 -37	3.7E3 - 3.3E4	8.9E-17 - 1.1E-18	10^{27} - 10^{28}	10^{-18} - 10^{-19}	Particles
6	Mg – K	38 – 45	6.7E4 - 2.7E5	5.6E-18 - 1.4E-19	10^{28} - 10^{29}	10^{-19} - 10^{-20}	
7	Ca – As	46 – 59	5.3E5 - 3.5E6	7.0E-19 - 1.1E-20	10^{29} - 10^{30}	10^{-20} - 10^{-21}	High
8	Se – Rh	60 -71	3.7E6 - 8.4E7	9.9E-20 - 1.1E-21	10^{30} - 10^{31}	10^{-21} - 10^{-22}	Energy
9	Pd – Eu	72 – 89	3.8E7 - 3.6E8	9.7E-21 - 1.0E-22	10^{31} - 10^{32}	10^{-22} - 10^{-23}	α-
10	Gd – Ac	90 - 115	3.9E8 -3.3E9	9.6E-22 - 1.1E-23	10^{32}- 10^{33}	10^{-23} - 10^{-24}	
1	Th –Am	116 -121	3.8E 8- 6.6E9	9.7E-23 - 5.7E-24	10^{33} - 10^{34}	10^{-24}	Particles

B. Other atomic physical properties

The waveform density ρ^*_w varies from 5.23 x 10^{-76} to 9.00 x 10^{-37} kg/m^3 for e to Am respectively; on the other hand, the isolated particulate atom is possibly the densest object in the cosmos. Values of ρ^o_p vary from 3.1 x 10^{35} to 1.2 x 10^{57} kg/m^3 for macroscopic visible e to Am respectively, while corresponding values for the microcosmic (i.e., vacuum) analogues are: $\rho'_p \cong \rho^*_p$ = 1.8 x 10^{34} to 2.8 x 10^{73} kg/m^3. For reason of space we are unable to present a detailed comparison between values of radiation densities of the vacuum obtained here and those predicted in cosmological models. Briefly, we note that unlike visible particulate forms, atomic waveforms are firmly held together by gravity as a result, the vacuum exists as a single cosmic superfluid, i.e., the photon [21]. Although each element retains its specific physical properties in the fluid, measurement would yield not the individual but sum total vacuum density ρ_{vac} = 2.608889474 x 10^{-36} kg/m^{-3} in reasonable agreement with the predicted values: Lemaitre, ρ_{vac} ~10^{-30} [22]; Einstein and de Sitter, ~10^{-31} [23]; and Alpher and Herman, ~10^{-35} [24]. It is important to note that the present value represents not the critical but *actual* vacuum density; notably, it confirms existence of the long speculated vacuum energy and yields $\Lambda = 8\pi\rho_{vac}G/c^2$ = 7.2955138855 x 10^{-52} m^{-2} in line with the observed value of ~10^{-52} m^{-2}. The SHM parameters: angular speed ω; centripetal force F; elastic modulus ϵ; longitudinal stress σ and strain τ are presented within the context of radioactivity.

C. Classical mechanics perspective of radioactivity

A summary of values of the atom's SHM parameters is presented in cols. 4 to 8, Table 1; the complete trends are illustrated in Figs. 3 to 10. The values follow the characteristic parabolic trend with an increase in Z, the details are examined.

1. Angular Speed

The waveform spins with angular speed ω_w that varies from 6.28 to 4.05 x 10^{10} rad/s for e to Am respectively while values for the corresponding macro- (ω^o_p) and microscopic particulate forms ω^*_p and ω'_p are 12.78 to 3.18 x 10^6 and 6.39 to 4.12 x 10^{10} rads/s respectively. We find here a clear indication that light spins at 6 rad/s as it radiates. From phosphorous P (Z_R = 41) to Am (Z_R = 121) the waveforms execute angular speeds in excess of a million rad/s with values rising incredibly to billions of rad/s along the periodicity. Observe that the wave and particulate forms spin independently and at different speeds; the difference becomes increasingly pronounced beginning with the element Ne (Z_R = 36) which marks onset of Russell's 5^{th} period. The results support our earlier observation that a major structural change occurs at Russell's 5^{th} period, i.e., "octave" and that the three ref. frames (U^*_r, U^o_r and U'_r) are mutually independent (orthogonal) yet interactive [6,7].

2. Other SHM Parameters

Values of the waveform's centripetal force F^*_w vary from 4.36 x 10^{-41} to 1.81 x 10^{-21} N for e to Am respectively; these values, of course, refer to the range of centripetal forces operating within the vacuum. For corresponding particulate forms we have F^o_p = 1.46 x 10^{-18} to 9.02 x 10^{-8} N and $F'_p \cong F^*_p$ = 3.64 x 10^{-19} to 15.12 N. Despite these predominantly low values, F plays key roles that decide major properties of the atom for instance, its interactions with atomic mass, strain and density give rise to gravitation, electricity and magnetism respectively. Strain rate τ on the waveform varies from τ^*_w = 2.12 x 10^{-7} to 1,368 % for e to Am respectively, note again that these values refer to the range of strain rates operating on atomic waveform envelopes within the vacuum. The corresponding values are: τ^o_p = 3.49 x 10^{15} to 8.67 x 10^{20} % for macrocosmic particulate forms, and $\tau^*_r \cong \tau'_p$ = 1.74 x 10^{15} to 1.12 x 10^{25} % for microcosmic particulate forms respectively; these incredible values decide radioactivity.

3. Classical Mechanics Factors that Govern Radioactivity

Fig. 3 shows that values of the atomic waveform's centripetal force F_w (or F^*_p), modulus ϵ_w, and stress σ_w converge gradually with an increase in Z value and become similar within the range Z_R = 90 to 99, i.e., elements Gd to Ta. In contrast, values of the same properties of the visible particulate atom diverge monotonously with an increase in Z value, Fig. 4. It is clear from the trends in Figs. 3 & 4 and Figs 5 & 6 that classical mechanics reveals that radioactivity results from changes in physical properties of the atom as Z value increases. Notably, the effect is a *microcosmic* phenomenon, the visible particulate atom plays no role whatsoever. The process involves the following three complementary mechanisms:

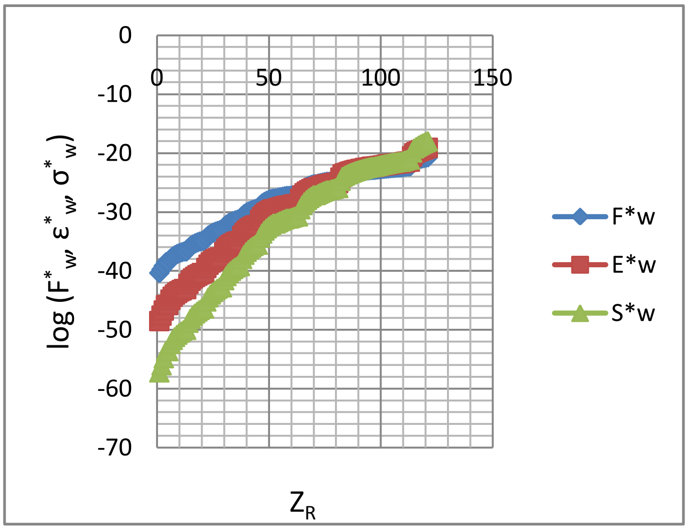

Fig. 3 Plot of log (F_w, ϵ_w and σ_w) vs. atomic no. Z_R – waveform

(a) *Convergence of absolute values of tensile properties of the microcosmic atom*

Values of physical properties of microcosmic forms of some heavy elements are listed in Table 3, the complete range is illustrated in Fig.3. As periodicity proceeds from e to Am, relative values of the waveform's tensile properties F_w, ϵ_w, and σ_w pass through a common point at Ac (Z_R = 115) where the stress field σ_w is able to overcome the restraining effects of the stiffness ϵ_w and centripetal force F_w holding the matrix together, here $\sigma_w \cong 2\epsilon_w \cong 10F_w$, the point, occurring at actinium Ac marks onset of spontaneous radioactivity.

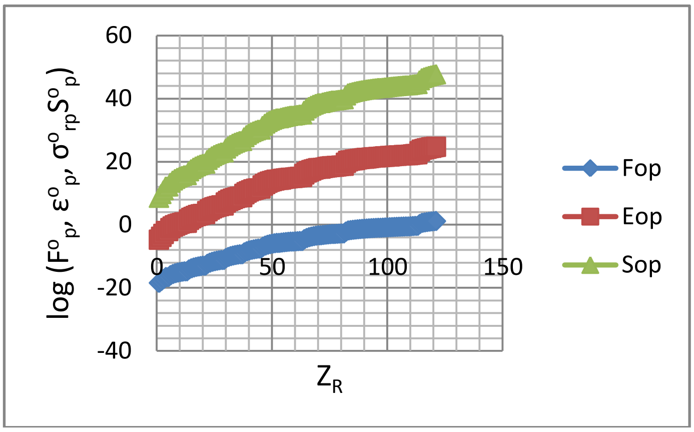

Fig. 4 Plot of log (F_p, ϵ_p and σ_p) vs. Z_R –particulate form

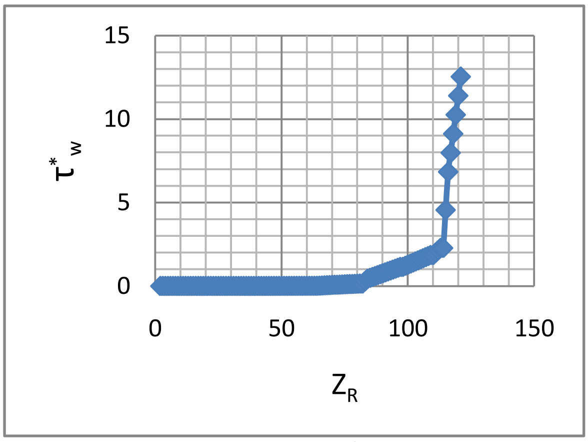

Fig. 5 Plot of τ_w vs. Z_R – waveform

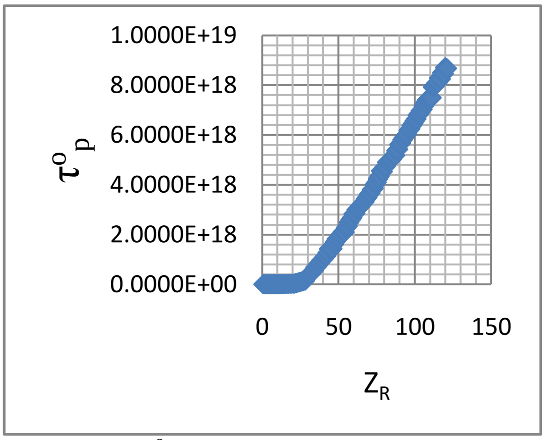

Fig. 6 Plot of τ^o_p vs. Z_R – visible particulate form

(b) *Critical rate of strain on the atomic waveform*

Fig. 5 shows that values of τ^*_w increase gradually from e's waveform value $\tau^*_{w(e)}$ = 2.12 x 10^{-7} to Xe (Z_R = 80)'s 143 % at which point it takes a sudden upward sweep and maintains the slope up to Ac (Z_R =115) where the value goes critical ($\tau^*_{w(At)}$ = 214 %, Table 3); this point (actinium) again marks onset of spontaneous radioactivity exactly as found for (a) above. We infer that at Ac strain rate on the local vacuum envelope (the "bosonic" waveform) encasing the particulate ("fermionic") matter reaches an elastic limit; once ruptured, matrix particulate content slowly leaks into space in spontaneous radioactivity.

(c) *Critical value of angular speed of the atomic waveform*

Variation of strain τ^*_w on the rotating waveform with angular speed ω^*_w is illustrated in Fig. 7. From e's $\omega^*_{w(e)}$ = 6.28 rad/s the atomic waveform achieves an angular speed in excess of 6 billion rad/s precisely at Ac, see Table 3. The evidence would suggest that 6 x 10^9 rad/s marks the critical value at which the rotating waveform acquires sufficient energy to engage the process of gradual attrition of its particulate content and eventual disintegration in spontaneous radioactivity.

If we assume the plum-pudding model, i.e., in the atomic nucleus particulate entities (fermions) are enclosed within corresponding waveforms (bosons) to form nuclides, radioactivity is explicable simply as a process whereby the bosonic waveform is strained to a breaking point under severe centrifugal force of the spinning matrix; fermionic nuclides are thereby released in quanta sizes that depend among others on the element. Decay half-life is thus understood in the context of gradual release of some 10^{20} strained molar pockets each containing 6.623 x 10^{43} units [6,7] at the rate of a few units per second in α-, β-, γ-, or other decay.

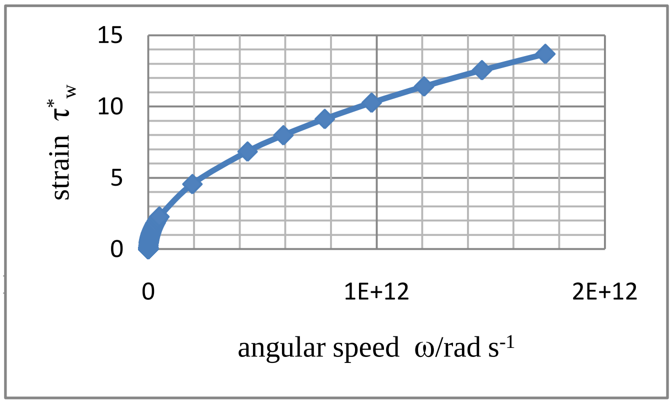

Fig. 7 Plot of strain τ vs. angular speed ω

TABLE 3: Physical properties of some heavy elements' waveforms

Atom	Russ. At. No. Z_R	Atomic Radius, r^*_w/m	Volume, v^*_w /m^3	Density, ρ^*_w kg/m^3	Angular Speed, ω^*_w /rads^{-1}	Centripetal Force, F^*_w/N	Elastic Modulus ϵ^*_w/Pa	Longtd. stress, σ^*_w/Pa	Strain rate, τ^*_w/%
Xe	80	2.234E+00	4.668E+01	1.060E-44	4.221E+08	1.965E-25	8.797E-26	1.254E-26	1.425E+1
Cs	81	2.234E+00	4.668E+01	1.060E-44	4.223E+08	1.965E-25	8.797E-26	1.254E-26	1.425E+1
Ba	82	1.117E+00	5.835E+00	1.696E-43	8.432E+08	7.859E-25	7.037E-25	2.006E-25	2.850E+1
La	83	7.445E-01	1.729E+00	8.585E-43	1.264E+09	1.768E-24	2.375E-24	1.015E-24	4.275E+1
Ce	84	6.599E-01	1.204E+00	1.391E-42	1.433E+09	2.251E-24	3.411E-24	1.645E-24	4.823E+1
Pm	87	4.922E-01	4.993E-01	4.497E-42	1.911E+09	4.047E-24	8.223E-24	5.318E-24	6.468E+1
Sm	88	4.537E-01	3.912E-01	6.226E-42	2.082E+09	4.762E-24	1.050E-23	7.364E-24	7.016E+1
Eu	89	4.208E-01	3.122E-01	8.412E-42	2.244E+09	5.535E-24	1.315E-23	9.949E-24	7.564E+1
Gd	90	3.924E-01	2.531E-01	1.113E-41	2.401E+09	6.367E-24	1.622E-23	1.316E-23	8.112E+1
Tb	91	3.676E-01	2.080E-01	1.445E-41	2.562E+09	7.256E-24	1.974E-23	1.710E-23	8.660E+1
Dy	92	3.457E-01	1.730E-01	1.848E-41	2.722E+09	8.203E-24	2.373E-23	2.185E-23	9.208E+1
Ho	93	3.263E-01	1.455E-01	2.328E-41	2.893E+09	9.209E-24	2.823E-23	2.754E-23	9.756E+1
Yb	96	2.792E-01	9.117E-02	4.342E-41	3.374E+09	1.258E-23	4.504E-23	5.135E-23	1.140E+2
Lu	97	2.792E-01	9.117E-02	4.342E-41	3.374E+09	1.258E-23	4.504E-23	5.135E-23	1.140E+2
Hf	98	2.642E-01	7.724E-02	5.415E-41	3.562E+09	1.404E-23	5.316E-23	6.405E-23	1.205E+2
Ta	99	2.507E-01	6.601E-02	6.677E-41	3.763E+09	1.560E-23	6.220E-23	7.897E-23	1.270E+2
W	100	2.385E-01	5.686E-02	8.148E-41	3.952E+09	1.723E-23	7.222E-23	9.637E-23	1.334E+2
Re	101	2.275E-01	4.932E-02	9.849E-41	4.141E+09	1.894E-23	8.325E-23	1.165E-22	1.399E+2
Os	102	2.174E-01	4.306E-02	1.180E-40	4.334E+09	2.073E-23	9.536E-23	1.396E-22	1.464E+2
Ir	103	2.082E-01	3.781E-02	1.404E-40	4.522E+09	2.261E-23	1.086E-22	1.660E-22	1.529E+2
Pt	104	1.998E-01	3.339E-02	1.657E-40	4.714E+09	2.457E-23	1.230E-22	1.960E-22	1.593E+2
Au	105	1.920E-01	2.963E-02	1.943E-40	4.911E+09	2.660E-23	1.386E-22	2.298E-22	1.658E+2
Hg	106	1.847E-01	2.641E-02	2.265E-40	5.103E+09	2.872E-23	1.555E-22	2.679E-22	1.723E+2
Tl	107	1.780E-01	2.364E-02	2.626E-40	5.292E+09	3.092E-23	1.737E-22	3.105E-22	1.788E+2

Pb	108	1.718E-01	2.125E-02	3.027E-40	5.482E+09	3.321E-23	1.933E-22	3.580E-22	1.853E+2
Bi	109	1.718E-01	2.125E-02	3.027E-40	5.482E+09	3.321E-23	1.933E-22	3.580E-22	1.853E+2
Po	110	1.595E-01	1.701E-02	4.072E-40	5.911E+09	3.851E-23	2.414E-22	4.816E-22	1.995E+2
At	111	1.489E-01	1.383E-02	5.366E-40	6.323E+09	4.421E-23	2.969E-22	6.346E-22	2.138E+2
Rn	112	1.396E-01	1.140E-02	6.946E-40	6.754E+09	5.030E-23	3.603E-22	8.215E-22	2.280E+2
Fr	113	1.396E-01	1.140E-02	6.946E-40	6.754E+09	5.030E-23	3.603E-22	8.215E-22	2.280E+2
Ra	114	6.980E-02	1.425E-03	1.111E-38	1.353E+10	2.012E-22	2.882E-21	1.314E-20	4.560E+2
Ac	115	4.653E-02	4.221E-04	5.627E-38	2.022E+10	4.527E-22	9.728E-21	6.655E-20	6.840E+2
Th	116	3.989E-02	2.658E-04	1.042E-37	2.364E+10	6.162E-22	1.545E-20	1.233E-19	7.980E+2
Pa	117	3.490E-02	1.781E-04	1.778E-37	2.702E+10	8.048E-22	2.306E-20	2.103E-19	9.121E+2
U	118	3.102E-02	1.251E-04	2.848E-37	3.044E+10	1.019E-21	3.283E-20	3.369E-19	1.026E+3
Np	119	2.792E-02	9.117E-05	4.341E-37	3.372E+10	1.257E-21	4.504E-20	5.135E-19	1.140E+3
Pu	120	2.538E-02	6.850E-05	6.356E-37	3.714E+10	1.522E-21	5.995E-20	7.518E-19	1.254E+3
Am	121	2.327E-02	5.276E-05	9.002E-37	4.054E+10	1.811E-21	7.783E-20	1.065E-18	1.368E+3

SUMMARY AND CONCLUSION

The results are summarized.

1. Wave-particle duality is to be understood in the wider context that every atom comprises complementary wave and particulate forms mutually interactive but geometrically orthogonal, each form is characterized by its specific de Broglie quantum wavelength.
2. The microcosm comprises wave and invisible particulate matter while the macrocosm comprises wave embedded particulate matter only. Physical properties of the vacuum are therefore characterized not by single but a range of values of properties of the combined wave and microcosmic particulate forms. The combined waveforms manifest as vacuum radiation whose wavelengths make up the e-m spectrum.
3. The isolated particulate non-bonded atom, free from influence of a field other than its own, is possibly the densest object in the cosmos with microcosmic particulate Am topping the list at an incredible 3.296×10^{73} kg m^{-3}. The microcosm thus consists of wave and particulate forms; the waveforms present as vacuum, its radiation (energy) gives rise to the CMB, while particulate forms present as *dark* matter and *dark* energy.
4. In contrast with the value of its radius in an external field, radius of the isolated atom decreases exponentially with an increase in Z value. Since literature values often refer to theoretical models or particulate (i.e., molar) matter, it is argued that effects of chemical environment such as bonding must be responsible for observed reverse trend.
5. In the context of SHM formalism light does not travel in the sense of rectilinear motion, it is an e-m harmonic oscillation; thus, cosmological distances are not distances of translation of the photon but accessible extent of electron waveform's cosmic permeation.
6. It is shown that the atom spins at incredible angular speeds, ω values range from 6.3 to 4.1×10^{10} rad/s for wave and 12.78 to 4.12×10^{10} rad/s for particulate forms; notably, each form rotates independently indicative of significant degree of geometric freedom between the three universes or reference frames.
7. Three mechanisms involving changes in values of the atom's physical parameters are revealed to account for radioactivity; in each case spontaneous radioactive decay is shown to commence at actinium in line with observation.
8. The present account of the radioactive process fits with an atomic model that identifies the wave and particulate forms with bosons and fermions respectively.

We conclude that the investigation has produced compelling evidence to affirm validity of Russell's ϑ values; their use facilitates classical (Newtonian) mechanics description of the atom. More significantly, SHM analyses using the ϑ values have yielded theoretical results that reproduce empirical values with remarkable accuracy. Based on the present approach it should be possible to develop a consistent classical atomic physics to complement quantum mechanics.

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APPENDIX: DEFINITIONS AND SAMPLE CALCULATIONS

I. DEFINITIONS

1. Forms and domains

   Two forms: wave and particulate. Three mutually interactive but orthogonal domains: microcosmic Absolute Ref. Frame U^*_{abs} plus its Relative Component U^*_r; macrocosmic Visible Ref. Frame U^o_r; and microcosmic Invisible Analogue of the Visible Frame, U'_r.

2. Absolute atomic mass

   $$m^*_{abs} = m^*_w = h\vartheta^*_{abs}/c^2, \quad (A1)$$

   where ϑ^*_{abs} (i.e.,ϑ^*_w) is given (Russell's original field values [5,7); h, Planck constant and c is speed of light in vacuum.

3. Relative atomic mass

   $$m^i_{p(E)}/g\ mol^{-1} = (m^*_{abs(E)}/g\ atom^{-1})/(m^*_{abs(H)}/g\ atom^{-1}) \quad (A2)$$

   where i, E, and H refer to domain, element, and hydrogen respectively.

4. Field and corresponding mass values

   Three field ϑ values for each domain: ϑ^*_w, ϑ^*_{p2}; ϑ^o_p, ϑ^o_{p1}, ϑ^o_{p2}; ϑ'_p, ϑ'_{p1}, and ϑ'_{p2}; subscript p1 refers to theoretical values, i.e., equilibrium conversion of the mole to constituent single atoms, see ref. [18]; $\vartheta^*_w = \vartheta^*_{p1} \cong \vartheta'_{p1}$ - they refer to microcosmic waveforms of U^*_{abs} and U'_r. The corresponding mass values are: m^*_{abs}, m^*_{p1}, m^*_{p2}; m^o_p, m^o_{p1}, m^o_{p2}; m'_p, m'_{p1} and m'_{p2}. Generally, $m^*_{p2} \cong m'_{p2}$, therefore only U^*_r values are provided to illustrate trends of microcosmic particulate forms.

5. Transverse radiation

For waveforms, c = 2.99792458 x 10^8 m/s; for particulate forms, c* = c^o = c' = 3.71535229 x 10^{-14} m/s obtained from "Einstein" plot, i.e., log ($h\vartheta^*_{r1}$) vs. log (m^*_{p1}), see ref. [5]; or calculated from the ratio $(h\vartheta^i_{p1}/m^i_{p1})^{1/2}$ where i denotes the particulate form's domain, i.e., U^*_r; U^o_r or U'_r.

III. QUANTATIVE EXPRESSIONS

i. $m^*_{p1(E)}$/g atom^{-1} = $m^i_{r(E)}$/g mol^{-1} * $m^*_{abs(H)}$/g atom^{-1}, (A3)

It converts molar mass g/mol to wave equiv. g/atom; $m^*_{abs(H)}$ is domain invariant unit (i.e., H atom's) molar mass [7].

ii. $\vartheta^i_{p1} = m^*_{p1}/m^*_{p(e)}$ = (m^*_{p1}/g.atom^{-1})/(7.372496678 x 10^{-48}g/(atom. Hz)), (A4)
where $m^*_{p(e)}$ = $(h\vartheta^*_{abs(e)}/c^2)/m^*_{abs(H)}$ and $\vartheta^*_{abs(e)}$ = 1.0 Hz [5], ϑ^i_{p1} is not relevant here, it is presented for illustration only.

iii. ϑ^i_{p2} = m^*_p x c^2_f/h, (A5)

where c_f refers to relevant transverse field, wave or particulate, i.e., c = 2.99792458 x 10^8 for waveform or 3.71353229 x 10^{-14} m/s for particulate form.

III. SAMPLE EVALUATION PROCEDURE USING H

$m^*_{abs(H)}$ = $h\vartheta^*_{abs(H)}/c^2$ = 6.62606957 x 10^{-27} x 2048/(2.99792458 x $10^{10})^2$
= 1.50988732 x 10^{-44} g/atom - microcosmic *wave* form.
$m^*_{p2(H)}$ = [$m^*_{abs(H)}/m^*_{abs(H)}$] x 10^{-3} = 1.0 x 10^{-3} kg/mol
$\vartheta^*_{p2(H)}$ = 1.0 kg/mol x (3.71535229 x $10^{-12})^2$/(6.62606957 x 10^{-27})
= 2083.262558 Hz - microcosmic *particulate* form
$\vartheta^*_{abs(H)}$ = 2048 Hz - microcosmic *wave* form, given see refs. [5,7].
$m^*_{p2(H)}$ = $h\vartheta^*_{p2(H)}/c^{*2}$
= (6.62606957 x 10^{-34} x 2083.262558)/(3.71535229 x 10-14)^2
= 1 x 10^{-3} kg/mol
$m^o_{p2(H)}$ = 2 x $m^*_{p2(H)}$ = 2 x 10^{-3} kg/mol, visible *molar* form, see [5].
$\vartheta^o_{p2(H)}$ = 2.0g/mol x (3.17535229 x $10^{-12})^2$/(6.62606957 x 10^{-27})
= 4166.525115 Hz – macrocosmic *particulate* form

Values so obtained for all elements were used in eqs. (1) - (7) to obtain values of atomic physical properties in Tables1, 2 and 3; they are collated for H atom below in Table 4.

TABLE 4: H-atom's field and mass values for SHM analysis

	ϑ^*_{abs}	ϑ^*_{r2}	ϑ^o_{r2}	ϑ'_{r2}
		e-m field/Hz		
U^*_{abs} (wave)	2048			
U^*_r (particle)		2083.3		
U^o_{r2}(particle)			4166.5	
U'_{r2} (particle)				2083.3
		Molar mass u /kg atom^{-1} or kg mol^{-1}		
U^*_{abs} (wave)	1.51 x 10^{-47}			
U^*_r(particle)		1		
U^o_{r2}(particle)			2	
U'_{r2} (particle)				1

Vacuum radiation c = 2.99792458 x 10^8 m/s – waveform

Molar radiation c* = c^o = c' = 3.71535229 x 10^{-14} m/s – particulate form