Do the exoplanet properties verify the oscillation symmetry ?

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Abstract

The oscillation symmetry is extended to exoplanets. A systematic study is done on a wide selection of data. The following properties: masses, periods, radii and distances, when known, are studied in order to check their agreement with oscillation symmetry. It is shown that the data indeed oscillate. The parameters allowing to fit the data are discussed. It is shown that the same shape describes the oscillations of very different mass objects.

Keywords: oscillation symmetry, exoplanet properties

1 Introduction

The validity of the oscillation symmetry to masses of fundamental particles and nuclei is justified since they result from Schrödinger equation containing two opposite forces: kinetic and potential [1]. Although there is no theory linking between themselves the masses of astrophysical bodies, it was recently shown that they too are connected by such symmetry [1-4]. The common property between the particles and astrophysical bodies is the existence of opposite forces acting in the astrophysical field that is gravitational forces and centrifugal forces related to their kinetic energies, and kinetic and potential interactions in the particle field.

The oscillation symmetry was also observed for several properties other than masses (radii, eccentricities, orbital periods, densities, temperatures) of many astrophysical bodies, although there no justification known for that. For example this symmetry was applied [3] to tentatively predict some properties of the putative ninth and tenth new solar planets.

Many exoplanets were observed, mainly through radial speed measurements and transit observation technics. The present paper studies many known exoplanet masses and other properties. It studies different data properties not considered in my previous papers. Each study concerns data belonging to the same system and classified for masses in increasing order. The possible oscillations in the mass spectra are studied using the following relation:

$$m_{(n+1)} - m_n = f[(m_{(n+1)} + m_n)/2] \qquad (1)$$

where n indicates the mass number, therefore $m_{(n+1)}$ corresponds to the (n+1) mass value. Two successive mass differences are therefore plotted versus their corresponding mean values. This representation is named "mass data" in what follows.

All variations including the "mass data" and variations of other different properties are plotted and their oscillations studied using the following formula. A normalised cosine function is used for the fits of the data:

$$\Delta M = \alpha(1 + cos(M/M_1))exp(\beta.M) \qquad (2)$$

where M/M_1 is defined within 2π. The oscillation period is P = 2 πM_1.

M is the variable $(m_{(n+1)} + m_n)/2$ and Δ M is the function for "mass data" studies.

α, β, and M_1 are the three fitted parameters. They are given in Table I. This function was used for all fits of all figs. except the fit of fig. 5(b).

2 Exoplanets within multiple planet systems

2.1 Some examples of Exoplanets connected to a Constellation stars

Fig. 1 shows some properties of the Eagle Constellation Exoplanets [5]. They are each exoplanet "b", orbiting around main sequence of giants and brown draft stars belonging to the Eagle Constellation. The stars are: HD 179079, CoRoT-8, WASP-80, HD 192263, HAT-P-41, WASP-74, Xi Aquilae, HD 192699, CoRoT-10, CoRoT-2, HD 183263, and CoRoT-3. In insert (a) their masses in Jupiter mass unit are plotted versus their distances in (ly) from Solar System. Their Periods in days are plotted versus their radii in Jupiter radius in insert (b). Insert (c) shows the corresponding masses versus the periods.

Fig. 2 shows some properties of the Andromeda Constellation Exoplanets [5]. They are each exoplanet "b", orbiting around a different star belonging to the Andromeda Constellation. The stars are: 14 Andromedae, Gliese 15 A, HAT-P-6, HAT-P-16, HAT-P-19, HAT-P-28, HAT-P-32, HAT-P-53, HD 1605, HD 5583, HD 5608, HD 8673 A, HD 13931, HD 16175, HD 222155, Kappa Andromedae, PA-99-N2, Qatar-3, Upsilon Andromedae, WASP-1, and WASP-33. In insert (a) their masses in Jupiter mass unit are plotted versus their distances in (ly). Their Periods in days are plotted versus their radii in Jupiter radius in insert (b). Insert (c) shows the corresponding masses versus the periods. Two well separated ranges of Andromeda Exoplanet periods are reported in [5]. There is no period data between these ranges. Since it is not possible to get a clear figure showing these both range data, the first range only is considered.

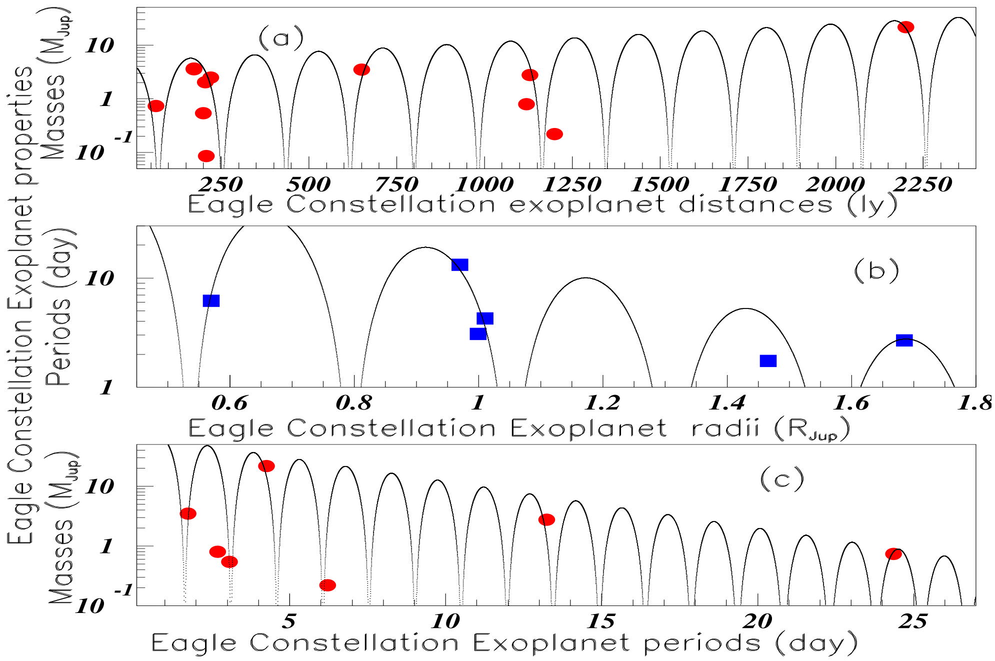

Figure 1. **Color on line. (See text). Eagle Constellation Exoplanet properties. Inserts (a), (b), and (c) show respectively their masses versus distances, periods versus radii, and masses versus periods.**

2.2 Some examples of Exoplanets related with a particular specification

The known exoplanet data from multiplanet systems are read in [6] using the list of exoplanets discovered by the Kepler space telescope.

In Fig. 3 a selection is done among the data discovered by Kepler. A first study of exoplanet data inside the oscillation symmetry has been reported in [3]. In the present work other data are considered more systematically, keeping systems with at least four exoplanets. Fig. 3 shows "mass data" from Kepler-341, -186, -208, -33, -286, -32, -3, -90, -102, -84, -85, -169, -55, and -292. Different markers and colors correspond to different multiplanet systems. For example, the four data for Kepler-341 lead to three marks shown by black stars on blue full circles. Different marks correspond to the other Kepler multiplanets. In order to keep clear the figure the many data showing the "mass data" are separated into two inserts. The parameters of the fits are reported in Table 1. The same period is observed in both inserts.

Several properties of different exoplanets, discovered using the Kepler space telescope, are plotted in fig. 4 [7]. Inserts (a), (b), and (c) show respectively the radii in Jupiter radius unit versus the exoplanet masses in Jupiter mass unit, the periods in days versus the exoplanet masses in Jupiter mass unit, and their density (in g/cm^3) versus their Semi-major axis (in AU). Different marks correspond to Kepler exoplanets: 80 in green

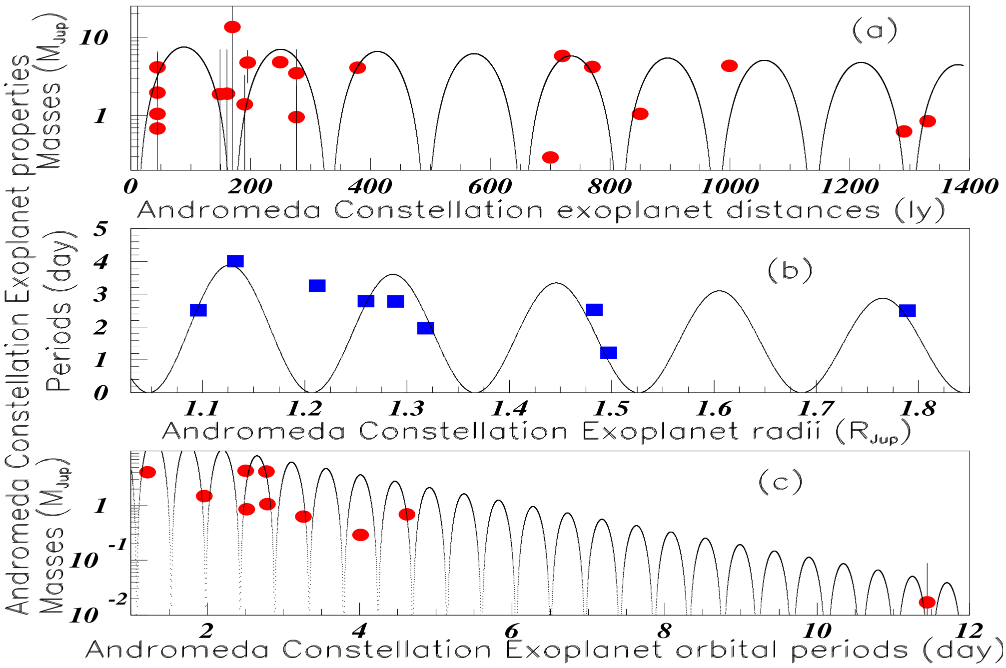

Figure 2. Color on line. (See text). Andromeda Constellation Exoplanet properties. Inserts (a), (b), and (c) show respectively their masses versus distances, periods versus radii, and masses versus periods.

up-side full triangles, 89 in full black stars, 79 in empty red circles, 62 in full red circles, 48 in empty purple crosses, 37 in empty black squares, and 11 in full blue squares.

Fig. 5 shows the data of the Conservative sample of potentially habitable exoplanets [8]. The data plotted are: Proxima Centuri b, Gliese 667 Cc, Kepler-4442b, Kepler-452b*, Wolf 1061c, Kepler-1229b, Kapteyn b*, Kepler-62f, Kepler-186, Luyten's, Trappist-1d, Trappist-1e, Trappist-1f, Trappist 1g, Kepler-1638b, Teegarden's Star c, Teegarden's Star b, and TOI 700 d. The corresponding masses and radii are often poorly determined, and therefore not considered. Other properties: distance from Earth (in ly), periods (days), equilibrium temperature (K), and Flux (Earth flux) are studied in Fig. 5. Inserts (a), (b), and (c) show respectively the exoplanet distances from Sun (ly) versus their periods (days), their equilibrium temperature in Kelvin units versus the Periods of potentially habitable exoplanets in day units, and their distance from Sun (ly) versus their flux (Earth flux). The fit in fig. 5(b) is obtained with a slightly different function:

$$T{=}\alpha + \beta.\cos(p/p(_1)) \qquad (3)$$

with the parameter values: α=225 K, β=50 K, and P=11.66 days.

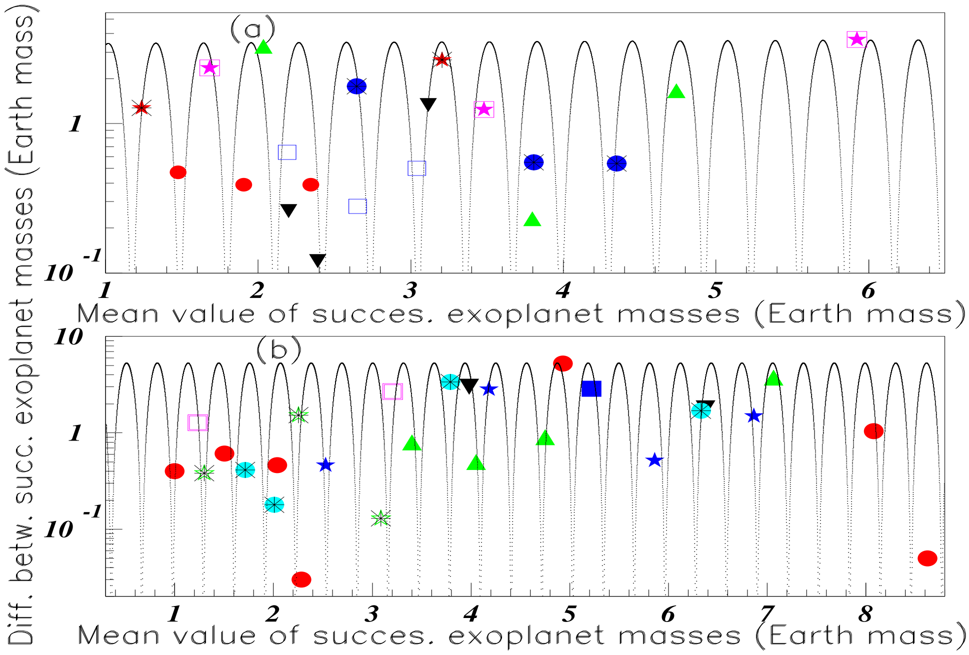

Figure 3. **Color on line. (See text). Several properties of multi exoplanet data plotted versus corresponding masses, discovered by the Kepler space telescope.**

Fig. 6 shows the 40 first Terrestrial exoplanet data of the Nasa catalog [6]. The Terrestrial exoplanets are defined to be those having their size between half Earth's size and twice Earth radius. The data used in fig. 6 are: Kepler- ** b, where ** stands for: 1141, 1152, 1169, 1173, 119, 11, 1222, 1235, 124, 1258, 1031, 1047, 1049, 1053, 1067, 106 b, 106 d, 1076, 1087, 1130, K2-223, K2-239 c, K2-257, K2-266, K2-315, K2-89, 1027, 102, 102 c, 102 f, EPIC 201497682, EPIC 201757695.02, EPIC 201833600 c, EPIC 206215704, EPIC 206317286, K2-116, K2-136, K2-137, K2-209, and K2-210. Fig. 6(a) shows their distance from Earth (in ly) versus the corresponding masses in Earth mass unit. Fig.6(b) shows the corresponding Stellar Magnitude versus the same masses.

Fig.7 shows the difference between successive Giant Gas exoplanet "mass data" versus the mean corresponding "mass data" in Jupiter units [6]. These are large exoplanets composed mostly by hydrogen or helium. The data containing at least 4 exoplanets are considered. Here again, different marks and colours correspond to different multiplanet systems. They are: black stars on full blue circles for 55 Cancri data, red full circles for HD 141399 data, empty blue squares for HD 27894 data, green full up-side triangles for HD 160691 data, black full down-side triangles for HD 160691 data, purple full stars inside empty purple squares for Upsilon Andromedae data, and green full stars over black stars for Ursae Majoris data. The "mass data" are well fitted.

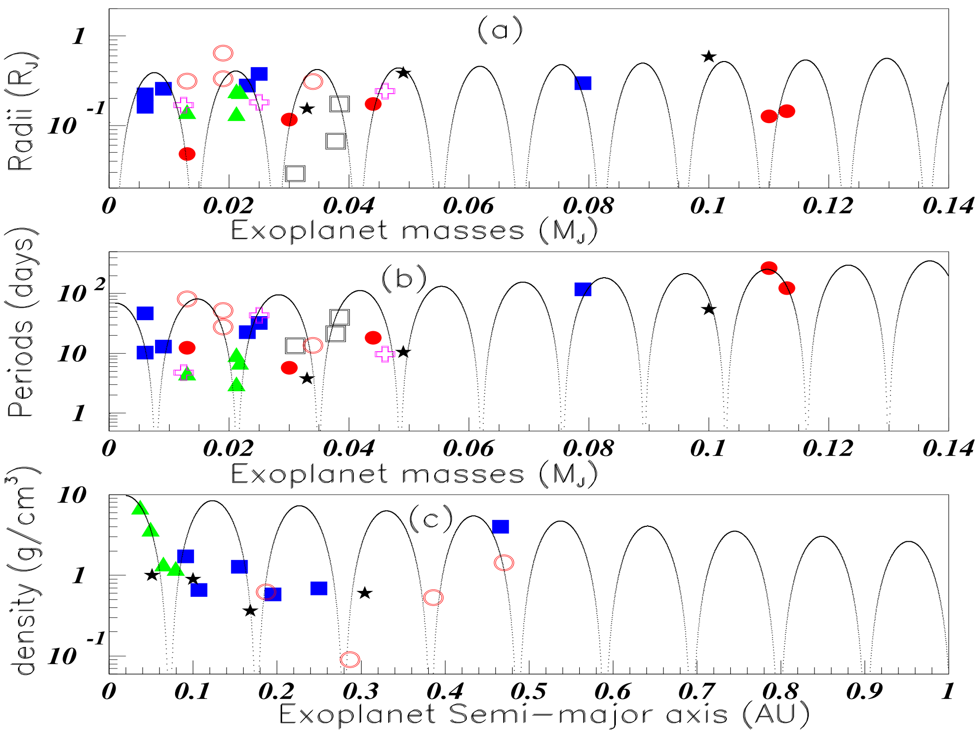

Figure 4. **Color on line. (See text). Several properties of multi exoplanet data, observed by the Kepler space telescope, plotted versus other properties of the same exoplanets.**

Fig.8 shows the difference between successive Super Earth (SEe) exoplanet "mass data" versus the mean corresponding "mass data" in Earth units [6]. These data correspond to a class of exoplanets which sizes are larger than the Earth size, and more massive than Earth (often rocky), yet lighter than corresponding Neptune properties. Data with less than 3 exoplanets are not considered. The Kepler data are: K-55 shown by green open stars, K-292 (blue full stars), K-85 (blue full circles), K-80 (red full circles), K-402 (green up-side full triangles), K-296 (black down-side full triangles), K-282 (purple full stars above purple empty squares), K-215 (red full star above black stars), K-208 (green full stars encircled by black empty circles), K-197 (full red circles encircled by black empty circles), K-186 (full blue squares), K-169 (up-side full black triangles), K-167 (down-side full black triangles encircled by black empty circles), and K-132 (purple empty stars).

The same curve fits also two larger "mass data" which are not included in the fig., otherwise the fig. will be too compressed. There is a rather good agreement between "mass data" and fit, although the first "mass data" of Kepler-80 (full red circle) in insert (a) is outside the fit just as the first Kepler-169 "mass data" (full black up-side triangle).

Fig.9(a) shows the Periods versus the radii of the Super Earth exoplanets studied in fig. 8. Different marks and colours correspond to different multiplanet systems. Full red circles show the K-55 data, full blue squares show the K-292 data, black full stars show

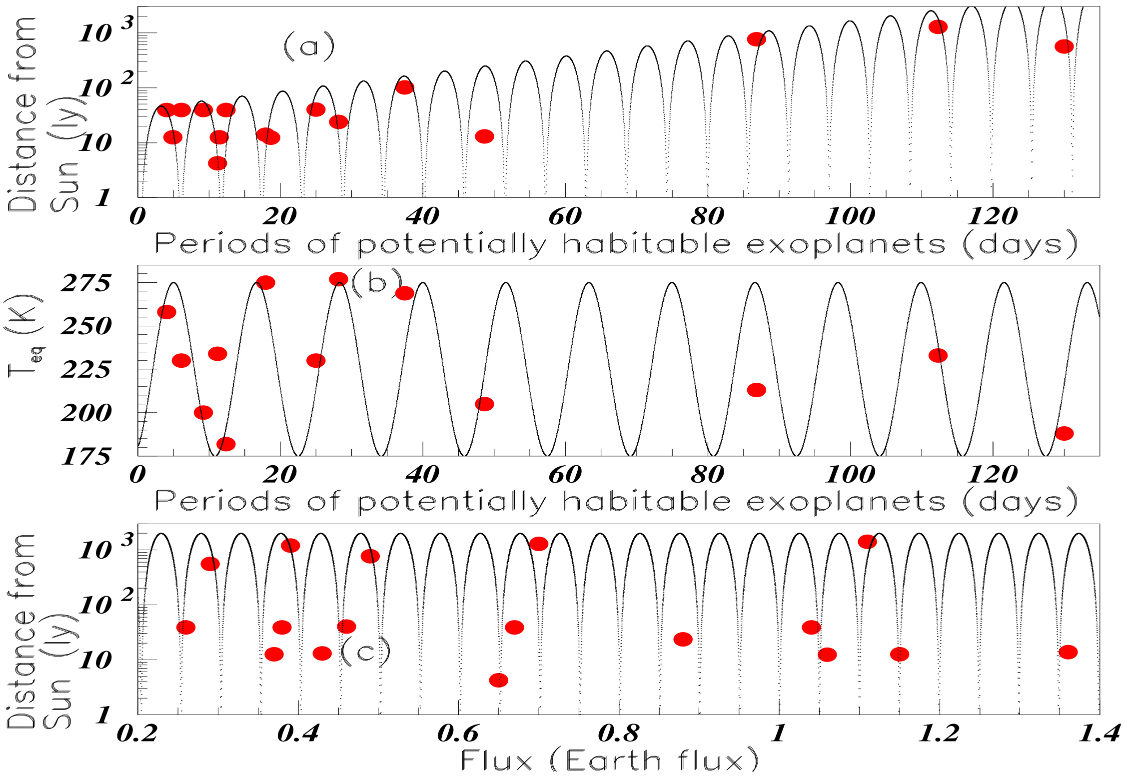

Figure 5. **Color on line. (See text). Potentionnaly habitable exoplanet properties. Inserts (a) and (b) show versus their periods in days respectively the Distance from Sun (in ly) and their Equilibrium temperature (in Kelvins). Insert (c) shows their distance from Sun (ly) versus the corresponding flux (in Earth flux unit).**

the K-80 data, green up-side full triangles show the K-85 data, purple empty squares show the K-186 data, black stars inside the empty black squares show the K-62 data, red empty cross show the K-215 data, and blue empty stars show the K-132 data. When the precision on the "mass data" (fig. 8) is good, it is not the case for the Orbital Periods. A few error bars only are introduced, otherwise the fig. becomes confused. Fig.9(b) shows Periods versus the masses of the Kepler Super Earth exoplanet masses in Jupiter mass unit [7], observed by the Kepler Space telescope with help of the transit explorary method. The large uncertainties prevent to give a negative jugment concerning the agreement between data and fit.

The candidate data for liquid water exoplanets are read [9]. They are reported in fig. 10. The following data are shown in the three inserts: 55 Cancri f, Proxima Centauri b, Gliese 581 c, Gliese 667 Cc, Gj 1214 b, HD 28185 b, HD 85512b, Kepler-62e, Kepler-62 f, Kepler-69 c, TRAPPIST-1d, TRAPPIST-1e, TRAPPIST-1d, and TRAPPIST-1e. Two data are ommited, since their large mass will compress the fig. These are M=266.9 earth

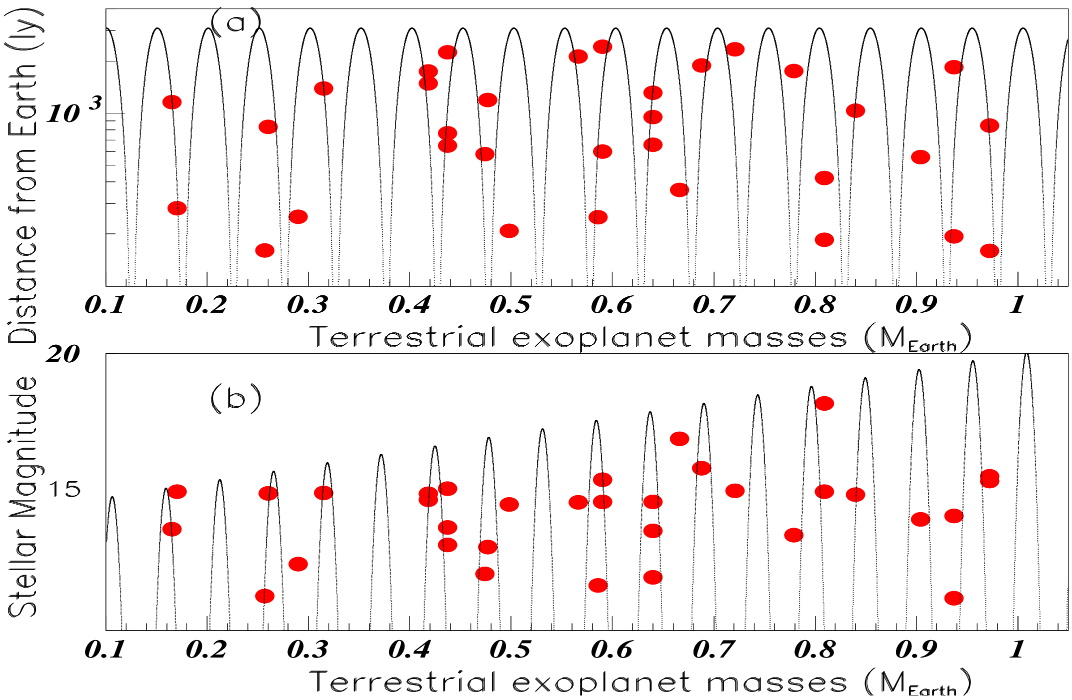

Figure 6. **Color on line. (See text). Terrestrial exoplanets properties. Inserts (a) and (b) show versus the corresponding mass respectively the Distance from Earth and the Stellar Magnitude.**

mass from COROT-9b and M=1811.46 earth mass from HD 28185 b exoplanets. The three inserts show respectively the data and fits versus the mass (in Earth mass unit) of period (days), Temperature (Kelvin), and Distance from Earth (ly). Most of them are well fitted.

3 Discussion

All previous figs. show general oscillatory behaviors, although a few data lies outside the corresponding fits. The oscillations are well fitted by a simple arbitrary cosine equation even better than anticipated when considering the large possible error bars.

The α and β parameters are connected and depend on the lowest abscissa, preventing any comparison between their values for different figs. The periods may be less affected by the previous remark. Figs. 3 and 8 show data and fits for different "mass data", selected inside several exoplanets around the same star in one side and Super Earth in the other side. The corresponding periods are quite close (they differ by 1%). Periods in Figs. 1(a) and 2(a) differ by only 6% from their mean value although they study different data (distance from Earth and Stellar Magnitude). Also the periods in Figs.10(a), 10(b), and 10(c) are quite close. However this proximity is not always observed.

Table 1. Parameters of the fits given in figs. See text. The parameters of fig.5(b) are given in the text.

Fig.	P unit	α	β	P
1(a)	ly	2.5	0.0008	182.2
1(b)	R_{Jup}	95	-2.5	0.258
1(c)	day	36.5	-0.18	1.48
2(a)	ly	3.9	-0.0004	161.5
2(b)	R_{Jup}	3.3	-0.47	0.160
2(c)	day	19.5	-0.59	0.452
3(a)	E_{mass}	1.7	0.01	0.312
3(b)	E_{mass}	2.65	0	0.312
4(a)	M_{Jup}	0.19	3	0.0136
4(b)	M_{Jup}	34	12	0.306
4(c)	S-m	5	-1.4	0.104
5(a)	day	20.5	0.037	5.69
5(c)	E_{flux}	1000	0	0.050
6(a)	E_{mass}	1550	0	0.050
6(b)	E_{mass}	6.7	0.4	0.053
7	M_{Jup}	0.23	0.81	0.327
8	E_{mass}	0.83	0.18	0.316
9(a)	R_{Jup}	2200	-22	0.028
9(b)	M_{Jup}	153	0.79	0.160
10(a)	E_{mass}	200	0	0.413
10(b)	E_{mass}	140	0.22	0.418
10(c)	E_{mass}	328	0.26	0.418

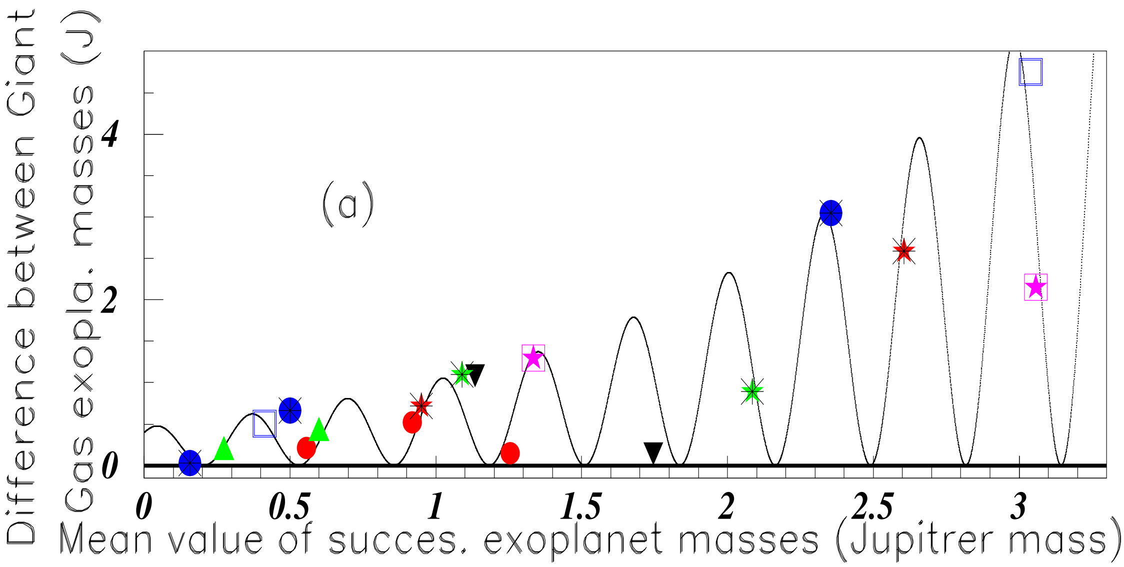

Figure 7. **Color on line. (See text). Giant Gas exoplanet "mass data".**

It has been previously shown that a same shape describes very different mass objects. So it was shown in fig. 20 of ref. [4] that the "mass data" of N(1/2), N(3/2), $\Delta(1/2)$, and $\Delta(3/2)$ baryons are well fitted by the same oscillatory shape. It is also the case for Total widths versus the masses of the same data.

It has also been shown that a same oscillaton shape is observed in "mass data" of different body family studies. Fig. 18 of ref.[4] illustrates this property for "mass data" of solar planets, Trappist exoplanets, quarks, and leptons, provided the masses are normalized by an homothetic factor.

Another similar property was shown in Fig. 19 of ref. [4] which is reproduced below in fig. 11. It shows that the following data are described by a same shape:

f_2 meson "mass data". Data (full blue squares) used for the fit.
f_0 meson "mass data". (homothetic factor 0.7). Full green stars.
Ξ baryon "mass data" (homothetic factor 0.94). Full red circles.
Ξ_c baryon "mass data" (homothetic factor 0.91). Full upside purple triangles.
^{14}N level "mass data" (homothetic factor 114). Black empty stars and empty squares.

These data are fitted with the relation:

$$\Delta M = \alpha_0 + \alpha_1 cos(M/M_1) exp(\beta.M) \qquad (2)$$

where α_0=190 MeV, α_1=120 MeV, β=-0.00035 MeV^{-1}, and P=414.7 MeV.

The present study shows that the same property is also observed in exoplanet "mass data".

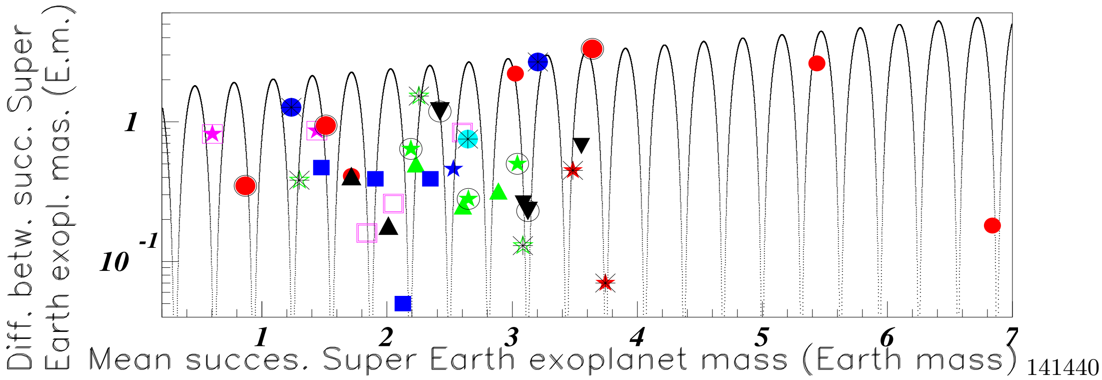

Figure 8. **Color on line. (See text). Super Earth "mass data".**

4 Conclusion

The main result of the present paper is the observation that the studied data oscillate. The study of oscillation symmetry started with the recall of oscillations resulting from the action of CLASSICAL two opposite forces acting on ONE body. These investigations extended to QUANTIC solutions of opposite forces acting on ONE body (quarks inside particles or nucleons, nucleons inside nuclei ...), and QUANTIC solutions acting on SEVERAL bodies like nuclei masses. Oscillations were then observed on other properties of the same systems like nuclei excited level widths.

Then this property is observed on SEVERAL CLASSICAL bodies belonging to the same system, provided that these bodies are submitted to opposite interactions. This observation opens a wide field of studies concerning various astrophysical bodies.

Such observation strengthens a previous observation that the oscillation symmetry is often observed in nature. The physical law behind this property is not understood to-day.

References

1. B. Tatischeff (2018),"Oscillation symmetry applied to: 1) hadronic and nuclei masses and widths, 2) astrophysics. And used to predict unknown data.", Proceedings of the 15th International Conference on Nuclear Reaction Mechanisms, Varenna (Italy), 35.
2. B. Tatischeff (2018), "May the oscillation symmetry be applied to TRAPPIST-1 terrestrial planets to predict the mass of the seventh planet ?", Phys Astron Int J. 2(3) 193. DOI: 10.15406/paij.2018.02.00085.
3. B. Tatischeff (2019), "Oscillation symmetry applied to several astrophysical data. Attempt to predict some properties of the putative ninth and tenth new solar planets", Phys. Astron. Int. J. 3(6):267-274. DOI:10.15406/paij.2019.03.00193.

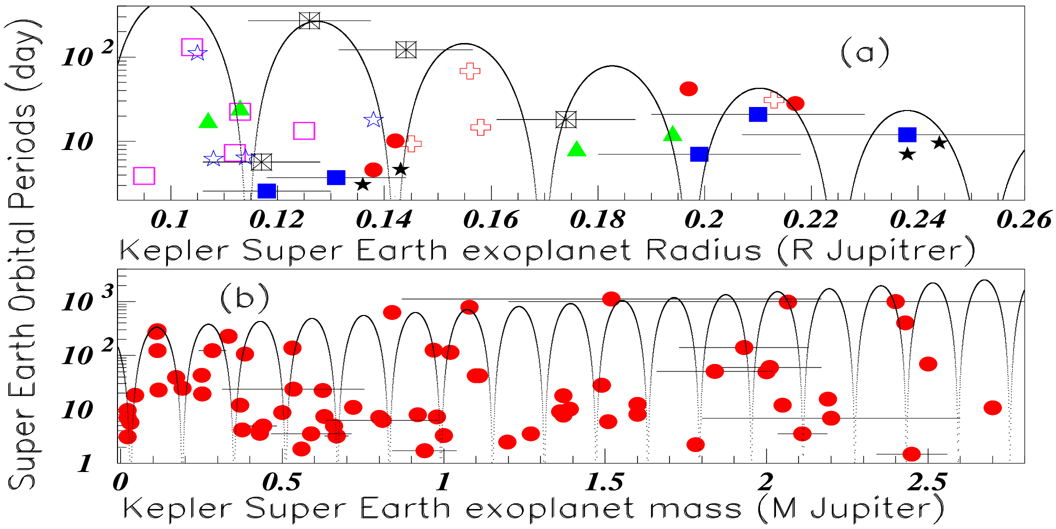

Figure 9. Color on line. (See text). Super Earth orbital periods in day units plotted versus the corresponding radii in jupiter radius unit in insert (a), and versus the correponding mass in Jupiter mass unit in insert (b).

4. B. Tatischeff (2020), "Oscillation symmetry applied to several astrophysical masses, and allowing to highlight remarkable relations between masses", Phys. Astron. Int. J. 4(2):93-105. DOI:10.15406/paij.2020.04.00206.
5. https://fr.wikipedia.org/wiki/Listes_d'exoplanets.
6. https://exoplanets.nasa.gov/discovery/exoplanet-catalog.
7. https://en.wiki /List_of _exoplanets_discovered_using_the_Kepler_space_telescope.M
8. https://en.wikipedia.org/wiki/List_of_potentionnally_habitable_exoplanets.
9. https://en.wikipedia.org/wiki/List_of_extrasolar_candidates_for_liquid_water.

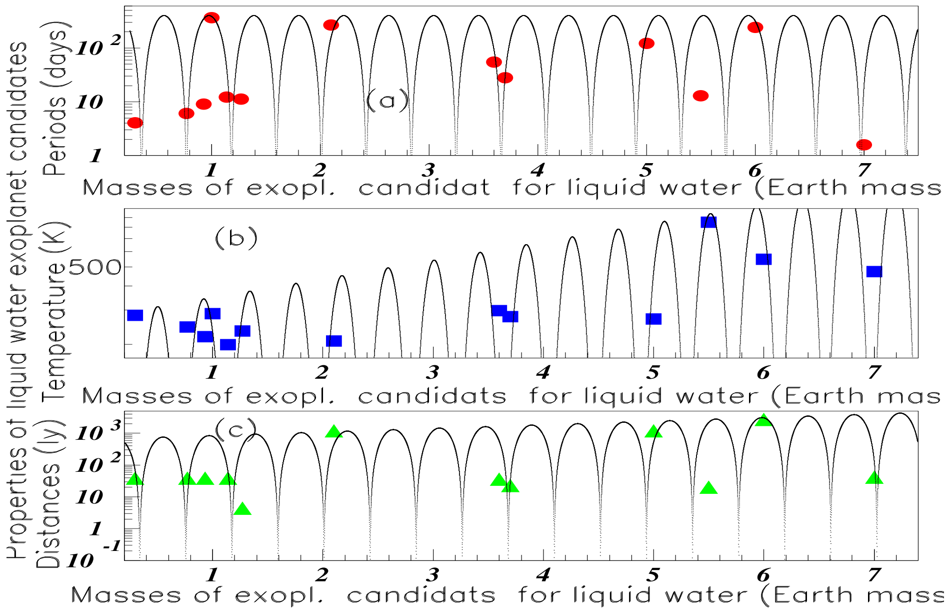

Figure 10. **Color on line. (See text). Exoplanets candidate for liquid water. The three inserts (a), (b), and (c) show respectively the data and fits versus the mass (in Earth mass unit) of orbital period (days), Temperature (Kelvin), and Distance from Earth (ly).**

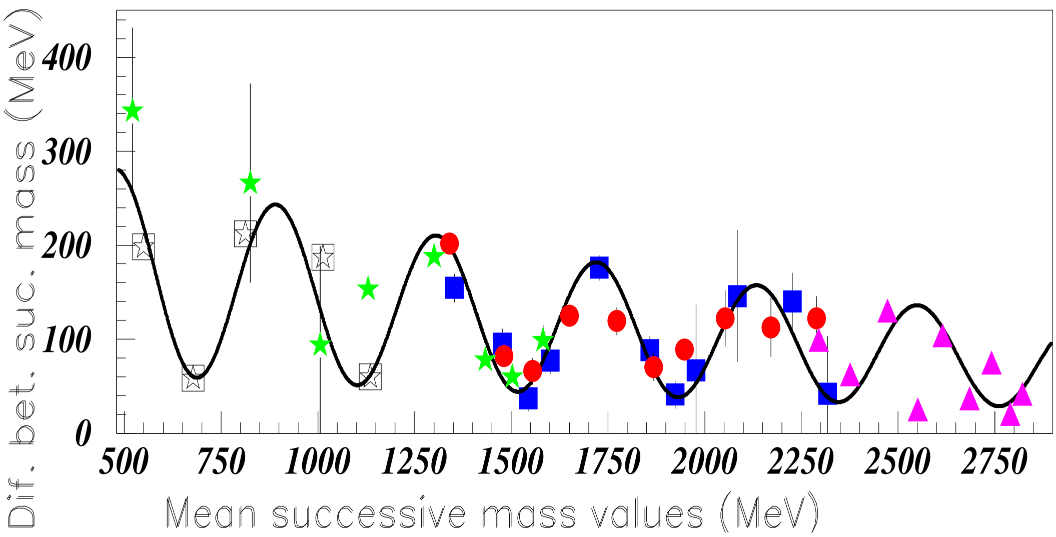

Figure 11. **Color on line. (See text). Comparison of "mass data" between several particle and nucleus families.**