Oscillation symmetry applied to: 1) hadronic and nuclei masses and widths 2) astrophysics, and used to predict unknown data.

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Abstract
A systematic study of given spin hadronic and nuclear masses shows regular oscillations observed when the difference between adjacent masses of each family is plotted versus the corresponding mean masses. The width variations, when plotted versus the masses, show the same behaviour. The oscillatory behaviour is also observed for astronomical data. This oscillatory symmetry is used to tentatively predict some unknown nuclear spins, and different properties of two new hypothetical solar planets.

1 Introduction

A new property of hadronic and atomic masses was recently shown [1, 2], namely that they obey to regular oscillations, fitted by simple cosine functions. Such property appears legitimated afterwards, since these bodies result from different smaller bodies (quarks and nucleons) which are subject to at least two different interactions, one attractive and one repulsive.

This property was observed for mesons, baryons [1], and nuclei [2] masses and widths [3]. Since the hadronic and nuclei masses result from the Schrödinger equation, with a kinetic and a potentiel interactions, like pendulum in classical physics, such observation could be predicted. The widths however of all these states do not arise simply from the Schrödinger equation.

The oscillatory behaviour quoted above result from the existence of opposite forces. Different opposite interactions are often observed in the nature. They are observed when a body results from the existence of several smaller bodies, like quarks and gluons for hadrons, or like nucleons for nuclei. Indeed the existence of opposite forces prevents the "large" bodies disintegration or self destruction.

Since the astronomic bodies are also subject to opposite interactions: gravitation and centrifugal forces related to the kinetic energy, their characteristics should also exhibit oscillatory properties. They will be studied below.

The mass variations are studied using the following equation, after having been classified in increasing order:

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

where $m_{(n+1)}$ corresponds to the (n+1) hadron mass value. Two successive mass differences are therefore plotted versus their corresponding mean masses.

The function used to the fits is:

$$\Delta M = \alpha_0 + \alpha_1 \cos((M - M_0)/M_1) \tag{2}$$

where M_0 /M_1 is defined within 2π. The oscillation periods, P = 2 πM_1 are studied. The amplitude of oscillations deserves theoretical studies which are outside the scope of the present work. The widths are plotted versus the corresponding masses.

The analysis requires the existence of several masses (at least five) having the same spin, without intermediate masses corresponding to particles with unknown spin. These restrictions limitate the appropriated data basis. Since many figures were shown in previous papers [2, 3], a selection is done to illustrate data not presented before, and particularly those allowing to predict some still unknown property of the considered particles.

2 Oscillations in hadronic masses and widths

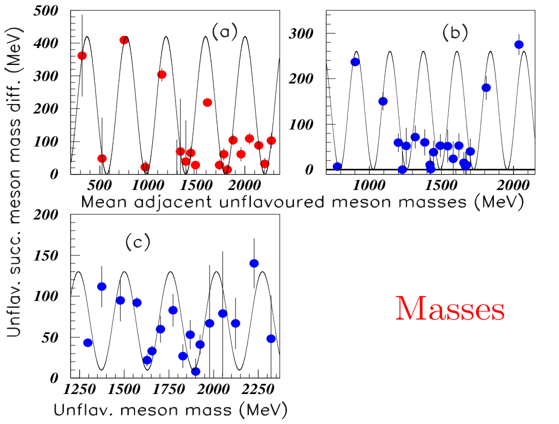

FIG. 1. Color on line. Unflavoured mesons. J=0, 1, and 2 for inserts (a), (b), and (c).

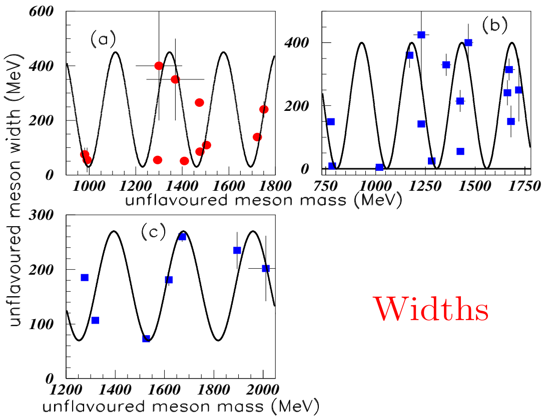

FIG. 2. Color on line. Unflavoured mesons. J=0, 1, and 2 for inserts (a), (b), and (c).

The data are read in the PDG tables [4]. Fig. 1 shows the successive mass differences of unflavoured mesons, plotted versus the mean corresponding masses. Inserts (a), (b), and (c) correspond respectively to spins J=0, 1, and 2. The mass periods decrease with increasing spins, from P=408 MeV to P=258 MeV. Fig. 2 shows the unflavoured meson widths plotted versus their masses. Here again, inserts (a), (b), and (c) correspond respectively to spins J=0, 1, and 2. The width periods increase with increasing spins, from P=232 MeV up to P=283 MeV. The oscillatory behaviour is clearly observed in all data.

Fig. 3 (Fig. 4) shows mass (width) data corresponding to strange mesons. Red full circles show the fitted data where masses, widths, and spins are known. There is a low mass strange meson with an unknown spin K(1630) I(J^P)=1/2($?^?$). This mass is successively introduced in the known data figures for different spins. In Fig. 3 the two new data are shown by stars (blue on line) surrounded by squares and in the same time one point, localized between the two new data (red encircled by black on line) should be removed. We observe that this new mass is more compatible with spins J=1 and J=2, than with J=0 (see fig.3(a)). Fig. 5 shows the Δ masses M (insert (a) et (b) for J=1/2 and J=3/2) and width W (insert

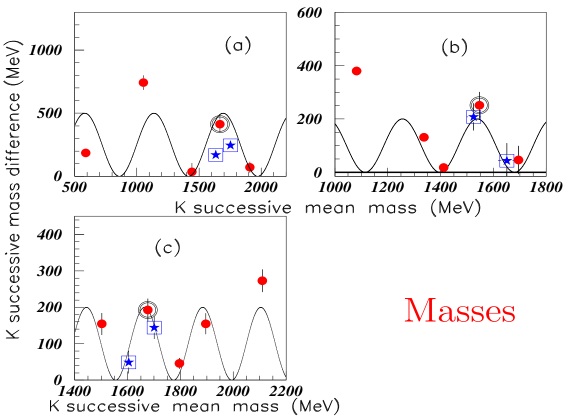

FIG. 3. Color on line. Strange mesons. J=0, 1, and 2 for inserts (a), (b), and (c).

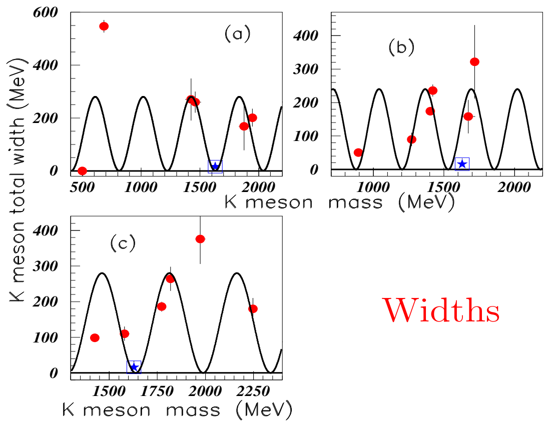

FIG. 4. Color on line. Strange mesons. J=0, 1, and 2 for inserts (a), (b), and (c).

(c) and (d) for J=1/2 and J=3/2 data. The data here are very well fitted.

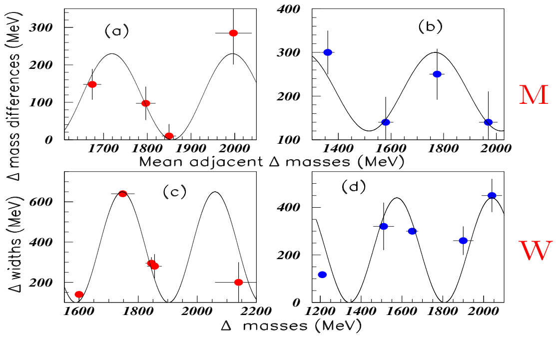

FIG. 5. Color on line. Δ baryons.
J=1/2 in inserts (a) and (c), 3/2 for (b) and (d).

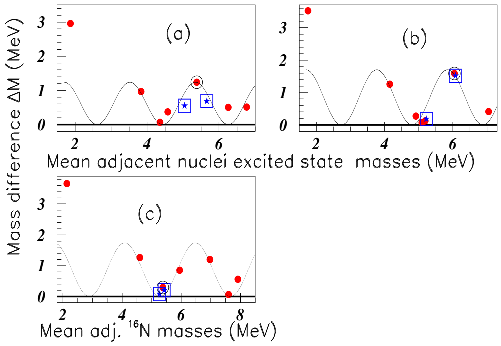

FIG. 6. Color on line. ^{16}N.
J=1 in (a), J=2 in (b), and J=3 in (c).

3 Oscillations in nuclei masses and widths

The very small widths of the first excited levels, which decay by weak or electromagnetic interactions, are omitted. This explains the large values of the first mass in the corresponding figures.

Fig. 6 shows the the mass differences of increasing ^{16}N excited level masses [5], plotted versus their mean values. Inserts (a), (b), and (c) correspond respectively to spins J=1, 2, and 3 respectively. Spin J=0 cannot be tested since their is only one J=0 state below M=5.318 MeV. The spin of the M=5.318 $\pm$0.03 MeV, Γ=260 keV is given to be (0^+, 1^+) [5]. The masses in Fig. 6(a) and the corresponding widths show that this spin is compatible with J=1.

Fig. 7 illustrates the possible determination of the spin of the M=9.72 MeV level of ^{15}O (1/2, 3/2)$^+$. Its mass and width are M=9.72 $\pm$0.050 MeV, Γ=1185 $\pm$ 50 keV [6]. From the mass figure the spin J=1/2 appears favored. This mass level is included in insert (a).

Fig. 8 shows the attempt to suggest the spin of the M=9.928 MeV level of ^{15}N. When introduced in the data describing the levels with known spin, fig. 8 shows the agreement with J=1/2 in mass and width figs., when it shows a disagreement with J=3/2. We conclude that the favored spin of this level is J=1/2.

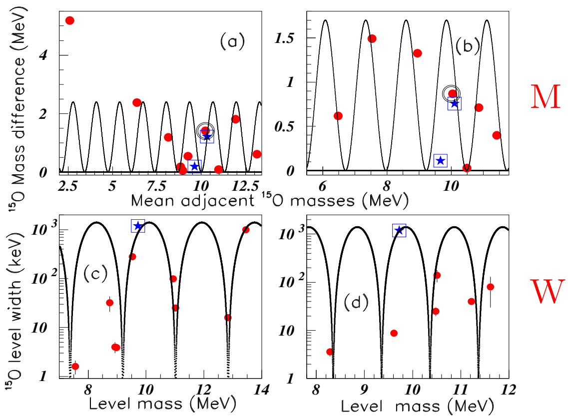

FIG. 7. Color on line. ^{15}O.
J=1/2 in inserts (a) and (c), J=3/2 for (b) and (d).

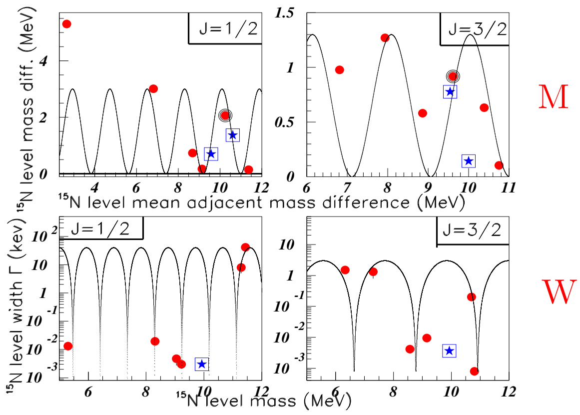

FIG. 8. Color on line. ^{15}N.
J=1/2 in (a) and (c), J=3/2 in (b) and (d).

4 Oscillations in astronomical bodies

The oscillatory symmetry was already used to predict the possible mass of the seventh planet around TRAPPIST-1 star observed in Ref. [7], namely that such mass should be M(7) $\approx$ 0.7 $\pm$ 0.1 earth mass [8].

We restrict here the discussion to tentatively predict the properties of the possible additional ninth and tenth solar planets. Their existence was suggested in order to explain the strange behaviour of some bodies belonging to the Kuiper belt, to stabilize several orbits of transneptuniens bodies, and to explain the Kuiper cliff behaviour. The prediction of their masses is: ten earth mass (em) for the ninth planet [9] (on line drawn in blue in the following figures), and half (em) (drawn in green) for the tenth planet [10]. Fig. 9 shows the successive solar planet mass differences [11], after classification along increasing masses, plotted versus the corresponding mean masses. Insert (a) show the data without introduction of these two new possible masses. Insert (b) shows the data with the new masses plotted by blue and green squares, where one has to suppress the black data corresponding to the mass difference of the previous sequence. The masses of these new planets are well fitted with the oscillations obtained using the "classical planet" masses. This agreement can be considered as an argument in favour of the existence of these two new solar planets.

Fig. 10 shows several possible properties of the anticipated ninth and tenth solar planets.

Fig. 11 shows some solar planet moon data for Saturn, Jupiter, Uranus. Neptune data are not shown, due to the small number of associated moons. The following relation (Pd)*$m^{-1/3} \approx 4.27(0.23)$ is observed for the four planets, where P is the period of the moon planet diameters plotted versus the moon distances from planet, d is the planet distance from the Sun (in astronomic units), and m the planet mass (in 10^{23} kg).

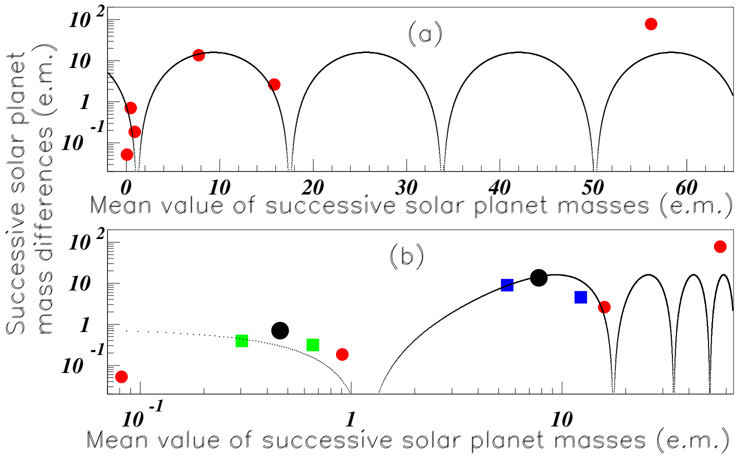

FIG. 9. Color on line. Mean value of successive solar planet masses (e.m.) plotted versus their mean value. See text.

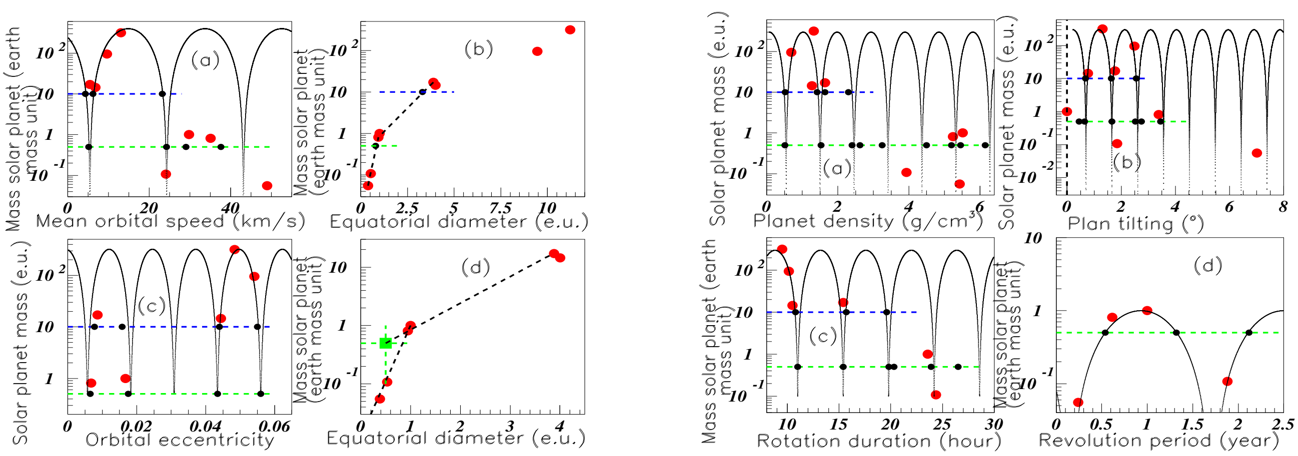

FIG. 10. Color on line. Different properties predicted for the two new possible solar planets 9 and 10.

Fig. 12 shows some solar planet ring data. The following relation P(ring)/r ≈ 0.234(0.014) (arbitrary units) is observed for the three planets, where P(ring) is the period of oscillations of the solar planet ring widths versus the planet ring radii, and r is the solar planet mean radius.

5 Conclusion

Regular oscillations are observed in masses and widths of particles, nuclei, and astrophysical bodies, although the forces acting in these different fields are very different. The existence of several data of the same family is a necessary condition for observing a regular behaviour.

The oscillations are fitted using cosine functions.

This oscillatory symmetry is verified in classical physics, quantum physics and astrophysics. Indeed the necessary condition is the existence of opposite interactions allowing the bodies to avoid their disintegration or fusion into a totally new object.

This symmetry can be used to predict still unknown properties.

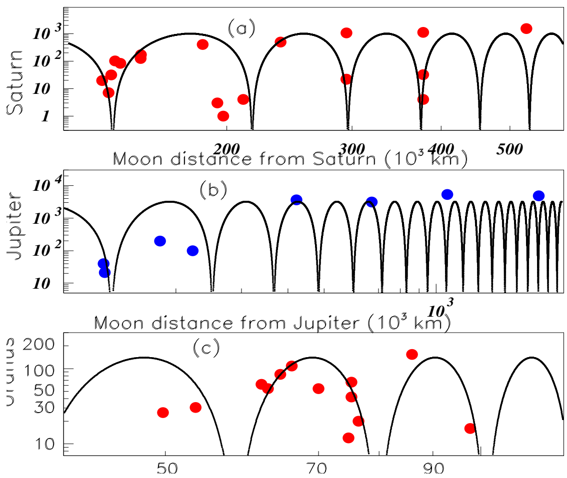

Fig. 11. Solar planet moon diameters plotted versus the moon distances from planet. Inserts (a), (b), and (c) correspond to Saturn, Jupiter, and Uranus data.

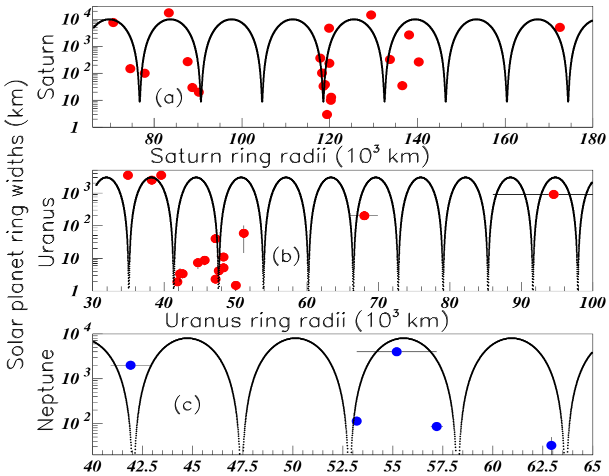

Fig. 12 Solar planet ring widths plotted versus the planet radii. Inserts (a), (b), and (c) correspond to Saturn, Uranus, and Neptune data.

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