

Application of oscillation symmetry to decay mode fractions of several mesons and baryons

Boris Tatischeff

Université Paris-Saclay, CNRS/IN2P3, IJCLab, Orsay Cedex, France

Abstract

The oscillation symmetry is applied with success to the decay mode fractions of several meson and baryons. The found periods display a "like quantification" behaviour.

1. Introduction

In the same way as opposite kinetic and potential forces produce oscillations in classical physics, they have also been observed in quantum physics. For example between masses and widths of elementary particles, and also in different other bodies and different other properties. So oscillations have been observed [1] in hadrons [2], [3], and in fundamental and excited state nuclei [4]. Oscillations have also been observed in the study of some physical properties of various hydrocarbons [5], and the study of several properties of astrophysical bodies [6]. They also have been observed [7] in E1 and M1 electromagnetic transitions, between different nuclei excited levels. In particle physics, the masses result through kinetic and potential interactions. In the astrophysical physics, the forces are gravitational and centrifugal, related to their kinetic energies. The common property of almost all bodies is that they are composed of smaller bodies.

This paper is devoted to the study of the oscillation symmetry applied to the decay mode fractions of several mesons and baryons. As done previously for mass studies, the decay values, read in [8], are classified by increasing values, ignoring the decay mode (hadronic,

Email address: `boris.tati@orange.fr` (Boris Tatischeff)

radiative or leptonic), allowing therefore to apply the oscillation symmetry studies. The (Γ_j/Γ) fractions are analyzed when a sufficient number of data exist for the concerned hadron. The very small ratios are not considered. Indeed they are known with large relative uncertainties. The hadronic decay modes are always used.

The possible oscillations are studied using the following relation:

$$(\Gamma_j/\Gamma)_{(n+1)} - (\Gamma_j/\Gamma)_n = f[(\Gamma_j/\Gamma)_{(n+1)} + (\Gamma_j/\Gamma)_n]/2 \quad (1)$$

where n indicates the increasing data order. The differences between two successive values are plotted versus their corresponding mean values. The data of such studies, corresponding to relation (1), are named "data".

A simple normalized cosine function is used for the fits of the data.

$$y = a(1 + \cos(x/x1))\exp(\beta.x) \quad (2)$$

where $x/x1$ is defined within 2π . The oscillation period $P = 2\pi.x1$.

α , β , and $x1$ are the three fitted parameters. Their values are given in Table A1. Afterwards all figs. and text use "data" as defined above.

2. Oscillation symmetry of decay mode fraction of some light unflavored mesons: $\pi 2$ (1670), $\rho 3$ (1690), and $a 2$ (1320)

The decay modes of light unflavored mesons are often reported without quantitative information, or only known with an upper limit. Fig.1 shows the oscillation symmetry analysis applied to a few light unflavored mesons where a not too small number of quantitative decay modes are known, although often with large imprecision. The decay mode fraction Γ_j/Γ "data" of several light unflavored mesons are plotted versus the corresponding mean "data". They are chosen since several decay mode fractions are quantitatively known, allowing the study inside the oscillation symmetry. They correspond to:

$\pi 2(1670)$ plotted with full red circle marks,

$\rho 3(1690)$ plotted with full blue square marks, and

$a 2(1320)$ plotted with full green upside triangle marks.

These data are well fitted with period $P=0.17$.

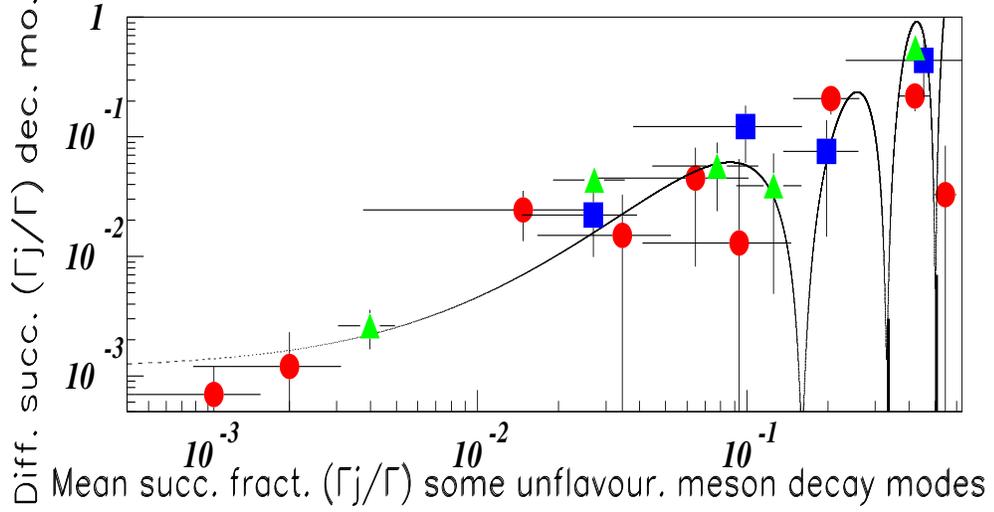


Figure 1: Color on line. (See text). The differences of decay modes fraction Γ_j/Γ "data" versus the corresponding mean values of several light unflavored mesons π_2 (1670), ρ_3 (1690), and a_2 (1320), are plotted versus the corresponding mean "data".

3. Oscillation symmetry of decay mode fraction of η , η' , and ϕ mesons

Fig.2 shows the oscillation symmetry applied to η , η' , and ϕ mesons. Insert(a) shows the differences of decay modes versus the corresponding mean values plotted using the following marks: full red circles for η neutral decay mode, full blue squares for η charge decay mode, and black stars for η' mesons. The data are well fitted with $P=0.11$, except the first three charged decay mode of the η meson which correspond to the first two blue squares.

Insert (b) shows the oscillation symmetry applied to decay mode fraction of ϕ meson. The data are fitted with $P=0.102$.

4. Oscillation symmetry of decay mode fraction of several strange and charmed charged mesons

The differences of fractional decay modes of some strange mesons are studied in fig.3. Their corresponding mean "data" are plotted using the following marks: full red circles for $D(1869.65)$ meson and full blue squares for D_{S1} (2460) meson, plotted versus the corresponding mean "data". These data are fitted with equation (2) and period $P=0.057$.

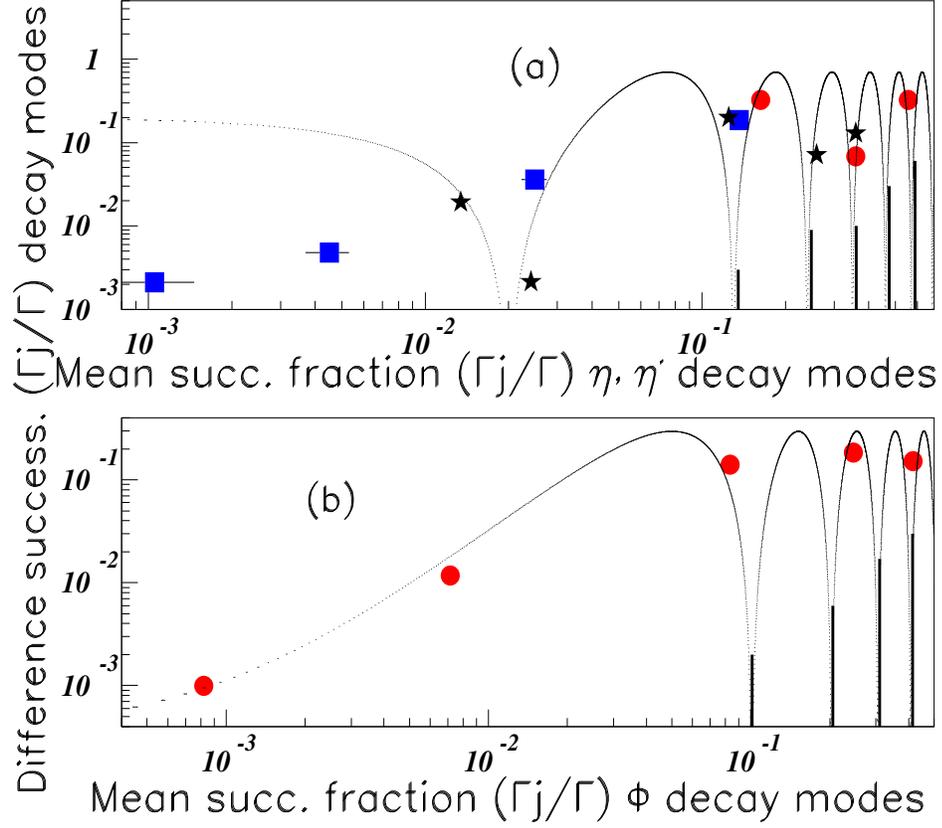


Figure 2: Color on line. (See text). The differences of decay modes versus the corresponding mean values are plotted using the following marks: full red circles for η neutral decay mode, full blue squares for η charge decay mode, and black stars for η' meson decay mode. Insert (b) shows the data for Φ meson decay mode.

5. Oscillation symmetry of decay mode fraction of J/Ψ mesons

The differences of fractional decay modes of several $(c - \bar{c})$ J/Ψ mesons are studied in fig.4. Their corresponding mean values are plotted using the following marks: full red circles for (1S) mesons, blue squares for (2S) mesons, and green triangles for (3S) mesons. The known corresponding data for (4S) and (5S) do not allow to extend this study. These data in fig.4 are fitted with equation (2) and period $P=0.056$, except the two small data of (3S) mesons.

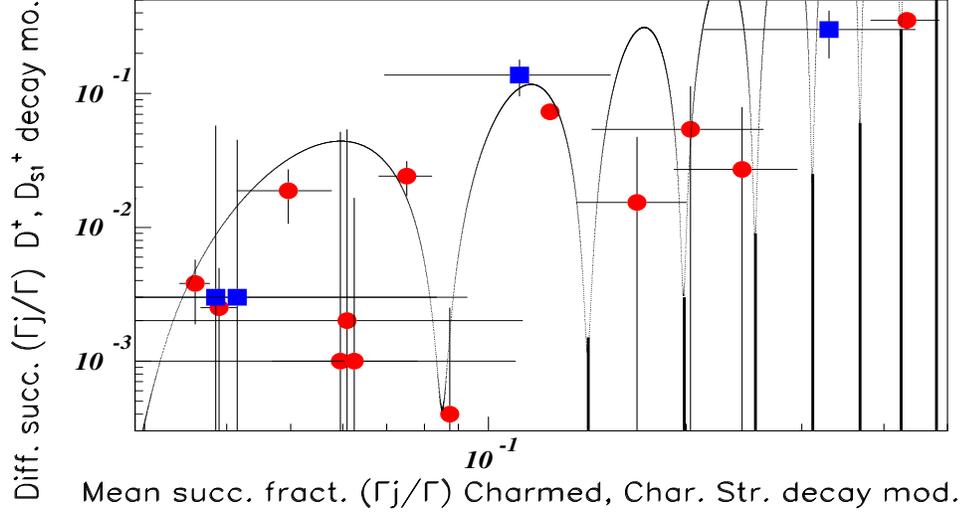


Figure 3: Color on line. (See text). The differences of decay modes versus the corresponding mean values are plotted using the following marks: full red circles for $D(1869.65)$ and full blue squares for $D_{S1}(2460)$ mesons plotted versus the corresponding mean values.

6. Oscillation symmetry of decay mode fraction of Υ mesons

Fig.5 shows the oscillation symmetry applied to the decay modes fractions (Γ_j/Γ) of the Υ mesons. The "data" are shown with full red circles for $\Upsilon(1S)$, full blue squares for $\Upsilon(2S)$, full upside green triangles for $\Upsilon(3S)$, full downside mauve triangles for $\Upsilon(4S)$, and full black stars for $\Upsilon(5S)$ mesons. The same fit obtained for the five different families; it reproduces well the data values with the period $P=0.055$.

7. Oscillation symmetry of decay mode fractions Γ_j/Γ of N baryons

The differences of N baryon decay mode fractions versus the corresponding mean values are plotted in fig.6(a) using the following marks: full red circles for $N(1520)$ and full blue squares for $N(1535)$ fitted with $P=0.081$; full red circles for $N(1650)$ and full blue squares for $N(1675)$ in fig.6(b) fitted with $P=0.214$. The small number of known heavier N baryons decay mode data, prevents, in order to get meaningful fits, to perform the same studies for heavier baryons, as $N(1700)$, $N(1895)$, $N(1900)$...

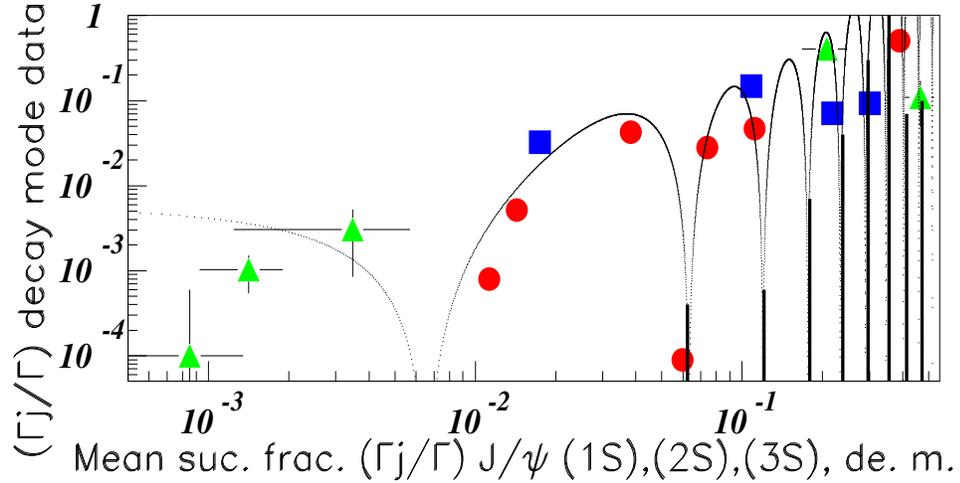


Figure 4: Color on line. (See text). The differences of decay modes of J/Ψ mesons are plotted versus the corresponding mean values using the following marks: (1S) mesons with red circles, (2S) mesons with blue squares, and (3S) mesons with green triangles. The known corresponding data for (4S) mesons and (5S) mesons do not allow to extend this study.

8. Oscillation symmetry of decay mode fractions Γ_j/Γ of Λ , Σ , and Ω baryons

Fig.7(a) shows the oscillation symmetry applied to the decay modes fractions (Γ_j/Γ) of the Λ (1520) (full red circles), and Σ (1189) baryons (full blue squares) fitted by $P=0.063$.

Fig.7(b) shows the oscillation symmetry applied to the decay modes fractions (Γ_j/Γ) of the Ω (1672.45) baryons fitted by $P=0.11$.

9. Oscillation symmetry of decay mode fraction of several Bottom baryons

The differences of several Bottom Baryon decay modes are plotted in fig.8 versus the corresponding mean values, using the following marks: full red circles for Λ_C (2280.5) and full blue squares for Λ_B (5619.6). The "data" for the Bottom, Strange mesons B_S^0 (5367), are added in this fig.8, through full upside green triangles, in order to check the possible same fit for baryon and meson analysis. These "data" are indeed well fitted. Some large data are not considered; the log scale involves their usefulness. The data are fitted using $P=0.0113$.

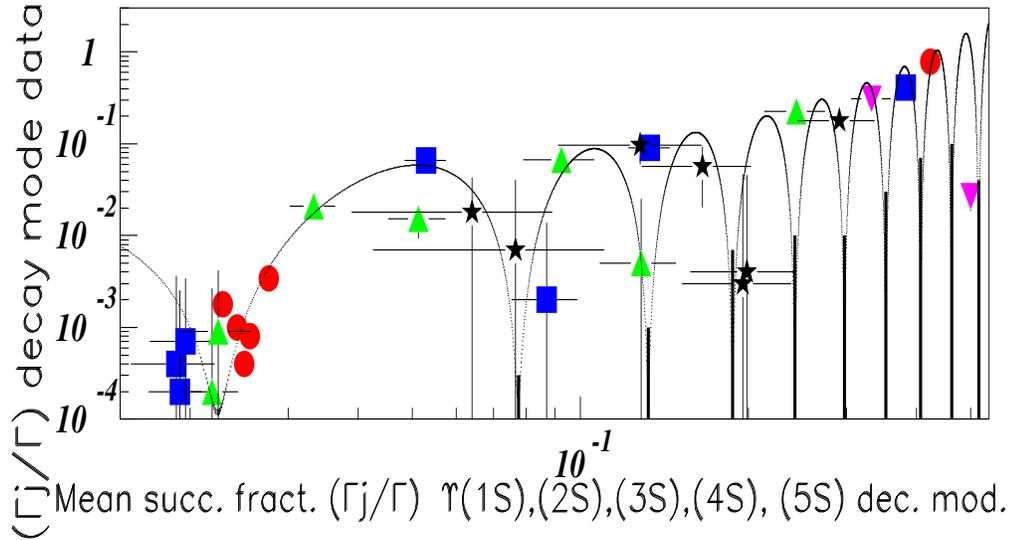


Figure 5: Color on line. (See text). The differences of decay modes of Υ mesons are plotted versus the corresponding mean values using the following marks: (1S) with red circles, (2S) with blue squares, (3S) with green triangles, (4S) with downside mauve triangles, and (5S) with full black stars.

10. Discussion and Conclusion

Table A1 gives the values of the parameters describing the data shown in figures. The periods are drawn in fig.9 versus the lower mass of the discussed hadrons. Full red circles corresponds to meson periods, full blue squares correspond to baryon periods. The fit performed on meson periods describe rather well the baryon periods.

In previous papers [9], [10] it was observed that the different found periods display a constant shift between themselves giving to think on a like "quantification effect". This is also observed here. The successive periods extracted from the present paper are drawn in fig.10. The meson periods are drawn in red, the baryon periods are drawn in blue. The horizontal dashed lines are separated by a constant value $c=0.023$. We observe again a like "quantification effect".

In conclusion, this paper shows new results in agreement with the oscillation symmetry, confirming its generalization property. These results confirm the previous observations that oscillations are widely observed in nature.

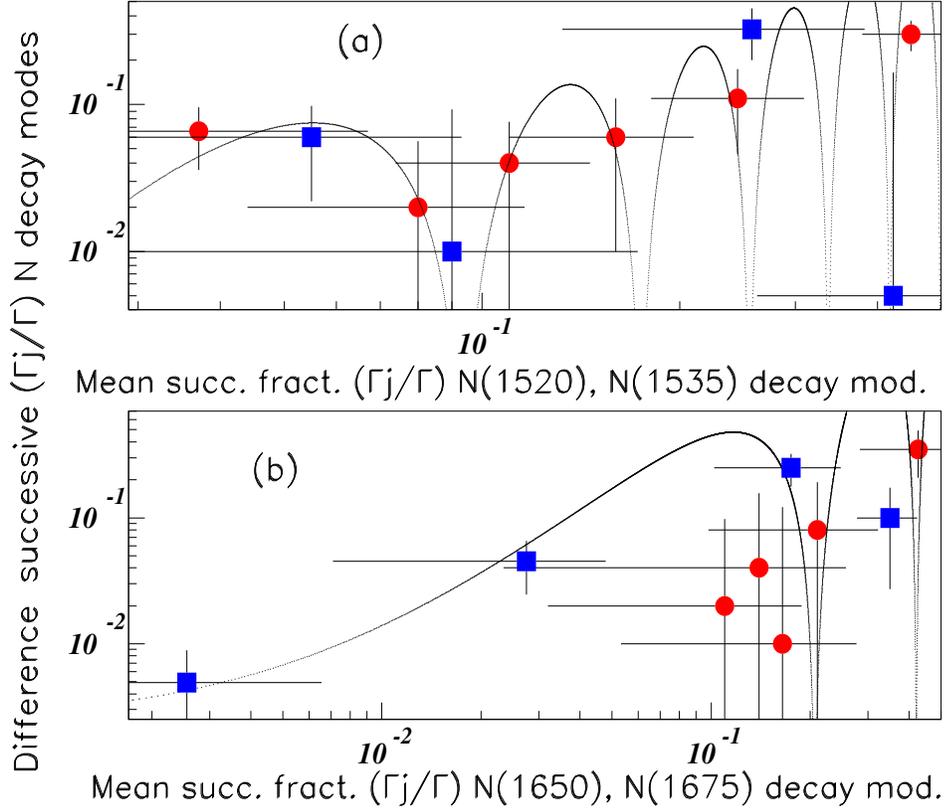


Figure 6: Color on line. (See text). The differences of N baryon decay mode fractions versus the corresponding mean values are plotted using the following marks: full red circles for N(1520) and full blue squares for N(1535) in insert (a), and full red circles for N(1650) and full blue squares for N(1675) in insert (b).

These results deserve theoretical studies, clearly outside the scope of the present work.

References

- [1] B. Tatischeff, "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).
- [2] B. Tatischeff, "Connections between hadronic masses in the one hand and between fundamental particle masses in the other hand", Journal of Advances in Applied Mathematics, JAAM V.5, N.3, <http://www.isaac-scientific.org>.
- [3] B. Tatischeff, "Hidden properties of meson and baryon masses and widths", <https://vixra.org/abs/2201.0004>.

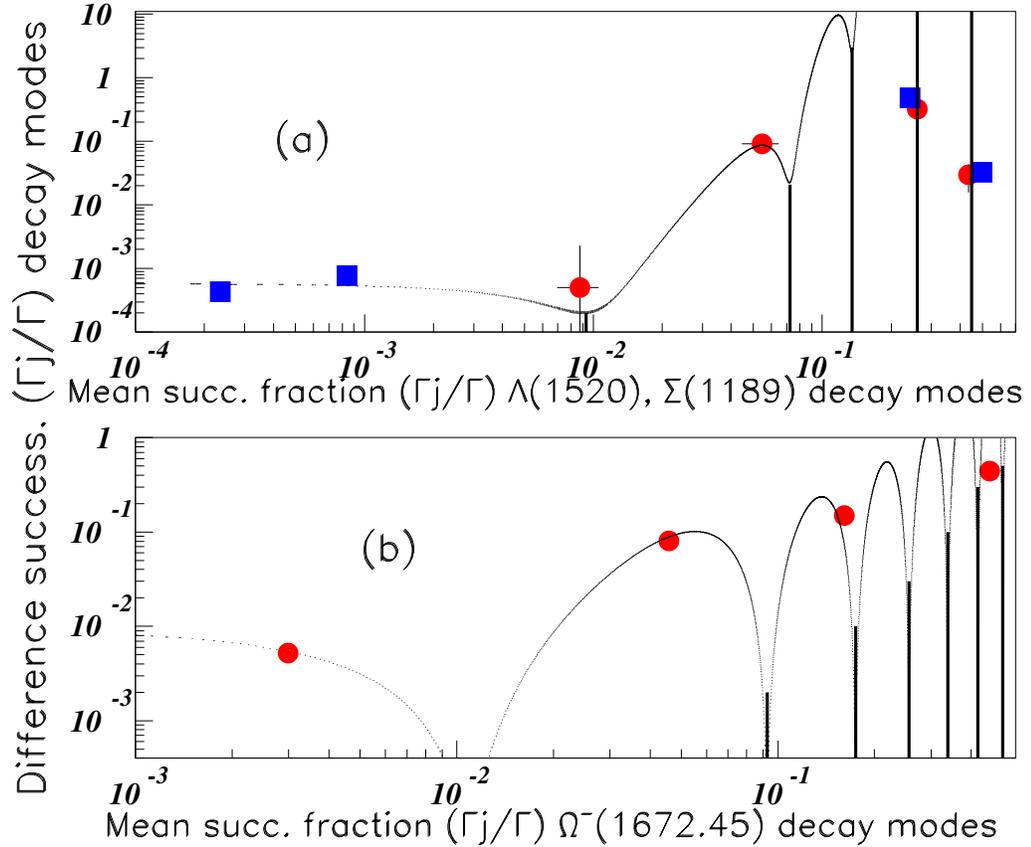


Figure 7: Color on line. (See text). The differences of Λ , Σ , and Ω baryons decay mode fractions are plotted versus the corresponding mean values using the following marks: full red circles for Λ (15230) and full blue squares for Σ (1189) in insert (a); and Ω (1672) in insert (b).

- [4] B. Tatischeff, "Observation of oscillation symmetry in nuclei excited state masses and widths", vixra.org/abs/2111.0010v1.
- [5] B. Tatischeff, "Test of Oscillation Symmetry applied to some physical properties of various Hydrocarbons", <https://vixra.org/abs/2206.00898v1.pdf> DOI:10.1506/
- [6] B. Tatischeff, "Oscillation symmetry applied to some astrophysical masses, and allowing to highlight remarkable relations between masses", Physics and Astronomy International Journal PAIJ-04-00206-2.pdf. DOI:10.1506/paij.2020.04.00206.
- [7] B. Tatischeff, "Application of the Oscillation Symmetry to the Electromagnetic Interactions of Some Particles, Nuclei, and Atoms", Journal of Advances in Applied Mathematics, Vol. 6, N. 2, 2021. doi.org/10.22606/jaam.2021.62003.

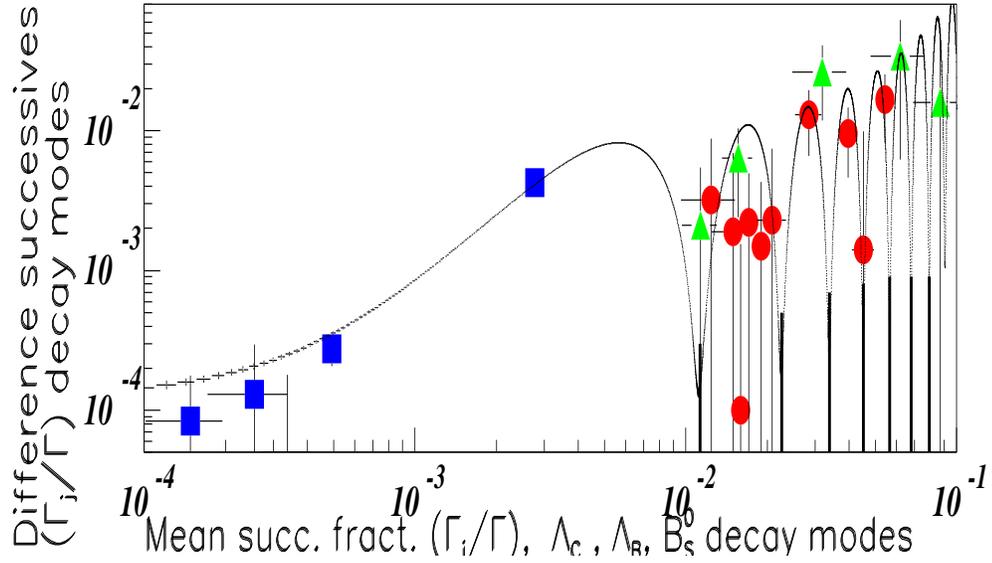


Figure 8: Color on line. (See text). The Differences of several Bottom Baryon decay modes are plotted in fig.8 versus the corresponding mean values using the following marks: full red circles for Λ_C , full blue squares for Λ_B , and full upside green triangles for B_S^0 .

- [8] Particle Data Particle Data Group, P. A. Zyla et al., Review of particle physics, Prog. Phys. 6 (2020) 083C01.
- [9] B. Tatischeff, "Application of the Oscillation Symmetry to Various Theoretical Hadronic masses", viXra.org/abs/2209.0034.
- [10] B. Tatischeff, "Where it is shown that the Oscillation Symmetry is also verified in the physical properties of the Periodic table of the Atomic Elements", vixra.org/pdf/2203.0113v1.pdf.

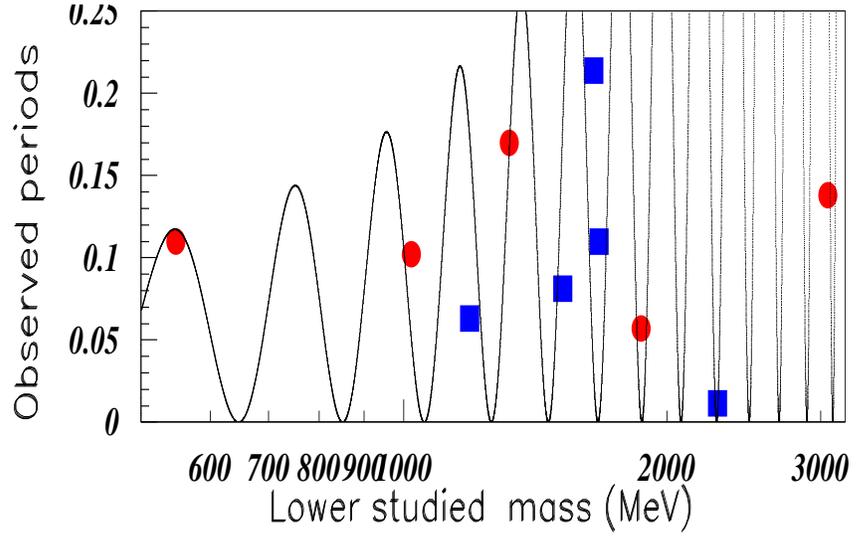


Figure 9: Color on line. (See text). Meson periods (in red) and baryon periods (in blue) versus the lower mass in MeV.

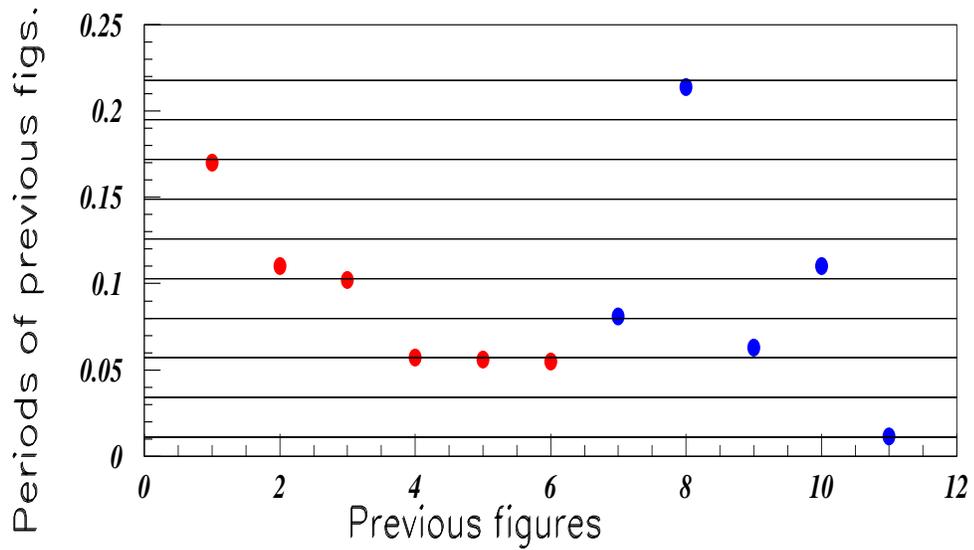


Figure 10: Color on line. (See text).

Table A1: Parameters of the fits

Fig.	α	β	P
1	0.016	7.96	0.170
2(a)	0.35	0	0.110
2(b)	0.148	0	0.102
3	0.008	17.3	0.057
4	0.022	13	0.056
5	0.02	7.5	0.055
6(a)	0.025	7.4	0.081
6(b)	0.106	7.5	0.214
7(a)	0.0011	75	0.063
7(b)	0.008	18	0.11
8	0.0035	26	0.0113