

The Double-slit experiment and Feynman Amplitudes to Interpret the Rise of Omicron at the Covid-19 Pandemic at 2022

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Abstract—As perceived at mostly countries, after the 3th or 4th wave of Covid-19 pandemic, its potential end might be coming. In contrast to previous waves, the last one exhibits different characteristics such as a highly exponential behavior or also a sharped Gauss behavior as seen at the huge number of infections at America and Europe. In this paper is proposed the idea that the whole pandemic is clearly composed by a sinusoid and Gaussian functions. This claim is based at the world-wide data that exhibits a similar shape with the proposed scheme at this study. Thus, the pandemic can also be seen as a signal-noise being the Omicron variant the signal whereas the previous mutations can be seen as their background events or noise.

Keywords—Covid-19, High Energy Physics, Randomness.

I. INTRODUCTION

A world-wide wave started at the end of 2021 mainly at Russia, UK, Germany, France and USA because the apparition of the so-called variant Omicron that firstly has appeared at South-African at last quarter of 2021 [1].

With the world exhibiting an apparent period of calmness in conjunction with the guarantee of most people have had up to three shots, a strong dynamics of intercontinental flights and the possible minimization of basic care and protection against the virus as well as still a vulnerable fraction of unvaccinated people, can be causes of the establishment of Omicron as the more deeply infectious strain seen to date [2].

The why Omicron can be considered as a super-infectious strain is probably the highest density of viruses per micro-droplet or individual aerosol. It is apparently largely and biggest than previous known strains. Clearly this virus exhibits a highly exponential shape as seen at various countries being very above the previous waves as seen at Fig.1 where the number of infections of whole pandemic can be associated to two different mathematical manifestations: (i) one of sinusoid character and (ii) another with a sharp peak similar to a Gaussian distribution. This simple distribution would have a clear origin at the argument of interaction virus-pepole, whose maximum peaks of infections has been seen violently exponential as seen from December 2021. A first sight at the world-wide data as seen at Fig.2 [3].

In this manner one can wonder why Omicron is more infectious than others? Recently have been proposed diverse mathematical mechanisms based at the well-known entropy of Shannon as well as the Bessel's functions [4]. In effect, because the morphology of data containing ups and downs and at some countries presenting Gaussian, Lorentzian profiles approximately, one can fairly argue that data actually

can be obeying some kind of polynomial distribution with their coefficients of random origin.

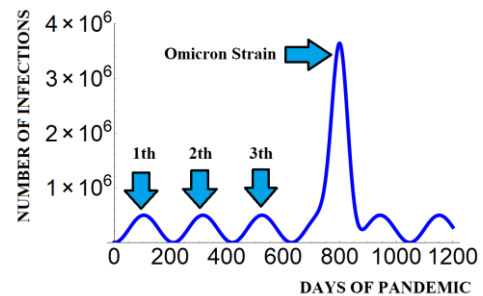


Fig. 1. Simple model of the world-wide data of infections by Covid-19 since the very beginning to date (First week of February 2022). The blue line is the simple sum of $\text{Sin}^2 + \text{Gaussian}$.

Interestingly in [5] data of new infections was modeled by distributions derived from entropy of Shannon that to some extent can explain the morphology of curves of infections. In fact, the introduction of Shannon's entropy comes from the fact that macro systems as countries involving a large amount of independent variables might be at interaction each other along the previous ones and first days of beginning of pandemic. Clearly the running of modern societies have as main component the human interaction to carry out and accomplish mandatory tasks to keep efficient the societies. In [6] the confirmation that Covid-19 disease is spread through the emission of virus through aerosols expelled while loud speech and talking are done in human to human conversation (interaction). This has demanded the implementation of the so-called social distancing that aims to keep 1.5 to 2.0 meters away from people in order to guarantee the healthy of social interactions. In [7] it was argued that conversations in an outdoor scenario while winds are running, might constitute a kind of potential case of infection. Here that infections are perceived as pure random events was launched. Thus the randomness of infection added to the action of human mobility, establishes a kind of stochastic scenario dictated by probabilistic rules more than deterministic.

In this paper the to date data of infections by Covid-19 is modeled by a continue function by the which is assumed that this is the composition of a $\text{sin}(\text{cos})$ and a Gaussian profile. Thus it is assumed that Omicron and people defines a well-defined interaction so that the resulting square of the sum of possible forms of interactions models well the distribution of Fig.1. The rest of paper is as follows: in second section the theory of Feynman is applied. In third section the results are presented and finally the conclusion of paper is presented.

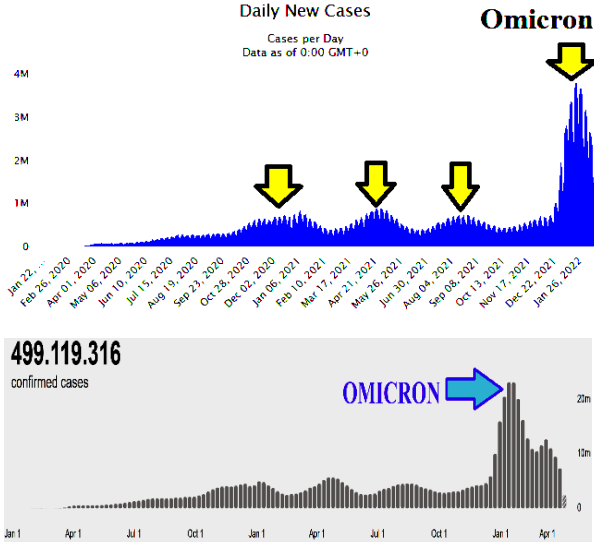


Fig. 2. Up: Official data of world-wide evolution of number of infections to date (First week of February 2022) by Covid-19. Down: Same but with data until First week of April 2022. Both plots are indicating the first 3 waves and the last one with a sharp and large peak attained to the variant so-called Omicron. It is interesting the clear similarity to the simple model as depicted at Fig.1

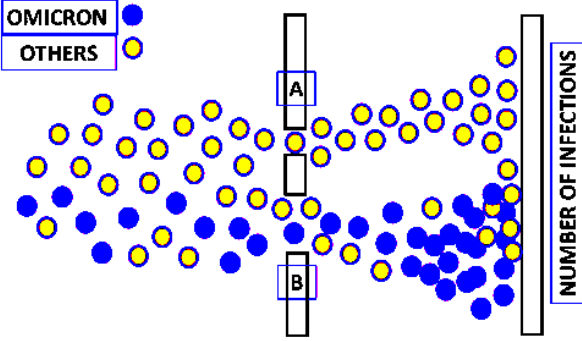


Fig. 3. A sketch about the hypothetical formation of the world-wide data of Covid-19 infections. The balls “Omicron” have more chance to pass through the slit “B” because it is wider than “A”, in this manner at the wall labeled “Number of Infections” one see more “Omicron” balls than the other case.

II. MATHEMATICAL PHYSICS INTERPRETATION OF VIRUS-HUMAN INTERACTION

A. The Concept of Square of Sum

Commonly in physics, if \mathcal{A}_1 and \mathcal{A}_2 denote two observables whose measurements can be done in an independent manner then

$$D(t) = \left| \sum_{q=1}^Q (t - \beta_q)^q \right|^2 + \left| \sum_{m=1}^M (t - \beta_p)^m \right|^2 + 2 \left| \sum_{q=1}^Q (t - \beta_q)^q \right| \left| \sum_{m=1}^M (t - \beta_m)^m \right| \quad (5)$$

$$D(t) = \left| \sum_{q=1}^Q (t - \beta_q)^q \right|^2 + \left| \sum_{m=1}^M (t - \beta_p)^m \right|^2 + 2 \left| \sum_{m,q=1}^{M,Q} (t - \beta_q)^q (t - \beta_m)^m \right| \quad (6)$$

It is possible to write down the square of terms of Eq.6 under the assumption that some terms are neglected. This is clearly a kind of approximation in order to form closed-form quantities. Thus the following ones can be seen as follows:

the square of the sum of them $|\mathcal{A}_1 + \mathcal{A}_2|^2$ might to denote a kind of probability but yielding the term $2\mathcal{A}_1 \otimes \mathcal{A}_2$ that is recognized as the interference. Clearly the sum of two entities is valid only if both are belonging to a same physical event such as shooting of balls through a wall containing two slides as sketched at the Fig.3.

Through this physics-based example one can see that at the wall “Number of Infections” there is a large number of “Omicron balls” because the slit “B” is wider than slit “A”. In this example the slits denote the human interaction with viruses. Clearly the slit “B” in this toy model reflects the fact that human is permissive to virus due to reasons and other points that are beyond the scope of this paper.

From Fig.3 one can postulate that the mathematical form of the pattern at the wall of left-side would follow a polynomial form dictated by:

$$- \text{Human} \quad \mathcal{A}_1 = \sum_{q=1}^Q (t - \beta_q)^q \quad (1)$$

$$- \text{Virus} \quad \mathcal{A}_2 = \sum_{m=1}^M (t - \beta_p)^m \quad (2)$$

The why of these polynomial forms follow from the signal extraction at High Energy Physics is explained at [8]. In fact, vaccines programs aims to reduce infections that can be seen as cuts to reduce the noise [9].

Here emerges the question: Why Omicron can be seen as signal? This idea fits well the well-known Feynman diagrams: [11][12][13][14]. Then the data (what is seen at the left-side wall of Fig.3) is modeled by the square of sum:

$$D(t) = |\mathcal{A}_1 + \mathcal{A}_2|^2 \quad (3)$$

The next task is the parametrization of each amplitudes as function of free parameters and time. In this way one can assing a kind of polynomial to them:

$$D(t) = \left| \sum_{q=1}^Q (t - \beta_q)^q + \sum_{m=1}^M (t - \beta_p)^m \right|^2 \quad (4)$$

A direct and trivial calculation of Eq.4 yields the square of each amplitude [15][16] and its respective interference, as written below:

$$\left| \sum_{m=1}^M (t - \beta_m)^m \right|^2 = 1 + (t - \beta_1) + (t - \beta_2)^2 + \dots \quad (7)$$

$$\left| \sum_{p=1}^P (t - \beta_p)^p \right|^2 = 1 + (t - \beta_1) + (t - \beta_3)^3 \quad (8)$$

Thus one can establish a Gaussian form for Eq.7 and the sinusoidal Sin at Eq.8. Consequently one arrives to:

$$\left| \sum_{m=1}^M (t - \beta_m)^m \right|^2 \approx \text{Exp} \left[- \left(\frac{t - \beta_A}{\delta} \right)^2 \right] \quad (9)$$

$$D(t) = n \left(\text{Exp} \left[- \left(\frac{t - \beta_A}{\delta} \right)^2 \right] + [A \text{Sin}(\beta_B t)]^2 + [A \text{Sin}(\beta_B t)]^2 \text{Exp} \left[- \left(\frac{t - \beta_A}{\delta} \right)^2 \right] \right). \quad (11)$$

It should be noted the incorporation of free parameters that would give an approximated morphology to the one of Fig.1. Thus β_A is denoting the date where is the peak of fourth wave caused by the Omicron variant. Here it is clear that β_B denotes the width of fourth wave. The β_B parameter modules the formation of consecutive waves as experienced by the first, second and third waves of pandemic [17][18]. The parameter A would describe the ‘‘intensity’’ of the previous waves. It is noteworthy that ‘‘ n ’’ is the top value of peak of whole pandemic. It is actually the most critic quantity along this debate. The resulting mathematical modeling given by Eq.11 of data displayed at Fig.1 can be interpreted as follows:

$$D(t) = 3500000 \left(\text{Exp} \left[- \left(\frac{t - 780}{150} \right)^2 \right] + [0.3 \text{Sin}(\beta_B t)]^2 + [0.3 \text{Sin}(\beta_B t)]^2 \text{Exp} \left[- \left(\frac{t - 780}{150} \right)^2 \right] \right). \quad (12)$$

III. RESULTS

In Fig.4 are displayed the 3D plot of Eq.12 (left-panel) and (right-side). The 3D plot is the number of infections versus the values of β_B parameter ranging between 0.01 and 0.02. The days of pandemic is considered between January 1th 2020 and December 31th 2022. It is approximately a period of 3 years. One can see that the main peak of pandemic occurs at the day 776 that is exactly February 16th 2022. The 3D gives the opportunity to see a possible end of pandemic as seen at the months of November 2022. The ongoing pandemic requires to fix $\beta_B = 0.015$. Concerning to the sharp peak of whole pandemic is dictated by Omicron, Eq.12 have demanded to employ $\delta = 150$ expressing the fact that the wave caused by Omicron might to have a peak with its tails in both left and right sides whose meaning is the beginning and end of 4th wave. Thus one can see that the possible end of 4th would be at the end of April 2022. At the right side of Fig.3 the corresponding to a 3D plot of Eq.12 for 1500 days indicating that next wave would be weak in contrast to the previous waves because is supposed the vaccination programs and the minimization of capabilities of Virus at time. In addition one can see that Omicron has the sharpest peak than the first 3 waves that are exhibiting a oscillant plane formed with respect to the values of β_B . The curved manifestation can be also understood in terms of

$$\left| \sum_{p=1}^P (t - \beta_p)^p \right|^2 \approx [A \text{Sin}(t\beta_B t)]^2 \quad (10)$$

It should be noted that the parameters β_A and β_B would have to be extracted from a fitting procedure on the data. Thus one can test all equations above in order to construct the potential function that is behind the global data. The one can write below

while the Gaussian term emerges as the output of an intrinsic process of convolution as seen at Eq.1, it is a potential candidate of fitting the Omicron data over the end of 2021 and the beginning of 2022. On the other hand the sin function is modeling the apparition of previous strains that would have to exhibit the apparition of protuberances corresponding the waves from the first up to the third at the beginning of 2021. In Eq.11. In order to get a numerical output of Eq.11 various values have been tested and therefore have been used as fitting numbers on the Eq.11 with a direct comparison to Eq.11. Below at Eq.12 the full equation that would correspond to global data is presented:

synchronization of the 3 first waves at the sense that not any one of the first 3 waves are cotrelated each one of them. It is entirely logic with apparition of the first 3 strains: China, UK, India. On the other side one can wonder about the purpose of having an interference term as given at Eq.2 In fact that term is rewritten as:

$$[0.3 \text{Sin}(\beta_B t)]^2 \text{Exp} \left[- \left(\frac{t - 780}{150} \right)^2 \right] \quad (13)$$

With a net contribution to Eq.12 of 0.009. So that at these conditions the interference do not play a relevant role at the modeling of global data. Actually the fact of the why the interference is almost negligible is because this can be perceived as the interaction of Omicron and the others strains along the period 2020-2022 turns out to be small. In terms strictly speaking at the language of amplitudes of probabilities, the coupling of the interaction can be recognized from Eq.13 being for this case of order of 0.009. In epidemiological terms this coupling is interpreted as the minimal interaction that experiences Omicron and the other strains. The fact that Omicron yields a large peak in the ongoing fourth wave is due to a rapid multiplicity of virus fact that explains the high rates of infections at most countries. In effect, it is also can be seen as the high probability of being infected with Omicron than other type of strain.

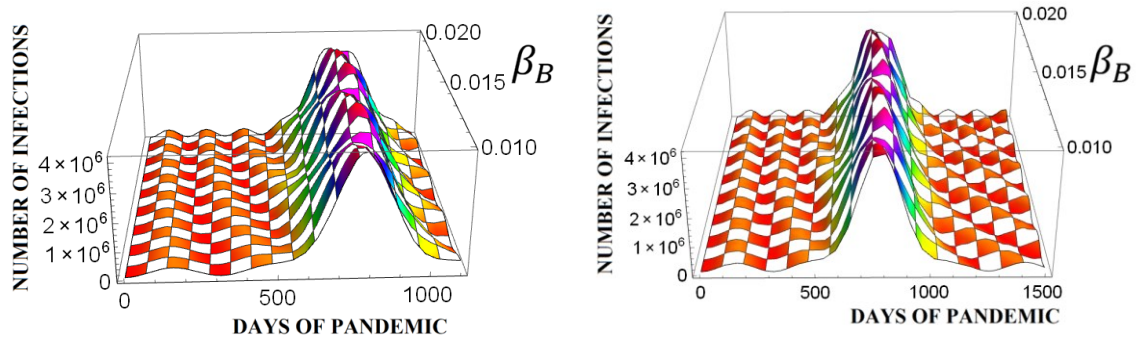


Fig. 4. (Left-side) The 3D plot of the number of infections for 1050 days from the beginning of pandemic versus the days of pandemic and the allowed values of β_B . (Right-side) Same as left-side but for 1500 days indicating the possible apparition of minor waves along the ongoing 2022. Both plots have been simulated with Mathematica [19].

IV. CONCLUSION

In this paper the analysis of global data of infections by Covid-19 to date has been treated. For this the theory of double slit has been employed. Thus the main idea of paper is that of the recent data of new infections dictated by the Omicron virus can be understood in terms of theory of balls thrown to a ball with a double-slit wall. Once the amplitudes have been proposed the central observable given by the world-wide number of infections has been modeled. The resulting simulations are in accordance with the ongoing data. Thus, the mathematical modeling agrees well with the apparition of peaks of waves at the years 2020 and 2021. The wave generated by Omicron emerges as the central and highest peak of the whole pandemic. On the other hand the possible end of pandemic turns out to be at November of 2022 as derived from the 3D plots and computational simulations. Clearly under this theory of double-slit, Omicron turns out to be the signal whereas the previous strains that have appeared at 2020 and 2021 might be perceived as the background as commonly used at theory of amplitudes and scattering in HEP [20].

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