The SARS-CoV-2 is a Weekly Multifractal : the Basic Indications and the Clinical Implications

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Abstract : We demonstrate that the SARS-CoV-2 is a multifractal and we study the implications of this discovery at the basic level as well as when this structure is intended for its function and when it could be used for test in the clinical applications depending the area of the singularity spectrum of the inspected virus and the other its characterizing parameters in each clinical case from the virulence of the virus.

Key words : Sars-CoV-2, multifractals, Sars-Cov-2 is a multifractal, Clinical evaluation of Multifractality of SARS-CoV-2.

Introduction

The novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) that emerged in Wuhan City , Hubei Province of China at the end of 2019, quickly spread to all Chinese provinces and, as of 4th of April, to 205 countries with over 1 million cases and approximately 60.000 deaths (https://www.worldometers.info/coronavirus/)
On 11th of March, World Health Organization (WHO) officially assessed that the COVID-19 can be characterized as a pandemic (https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020) .

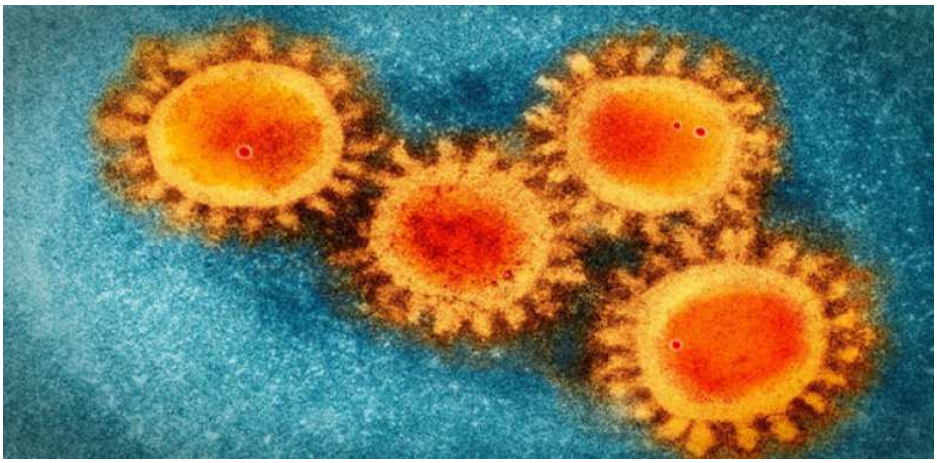
In the world, there are valuable efforts to combat the virus but, given the many uncertainties regarding the basic studies on the virus and its pathogen transmissibility and virulence, the effectiveness of these efforts is unknown. SARS-CoV-2 is transmitted via respiratory droplets. Fever, cough and fatigue are among the mostly observed symptoms (Guo et al., 2020). The fraction of undocumented but infectious cases is a critical epidemiological characteristic that modulates the pandemic potential of an emergent

respiratory virus. These undocumented infections often experience mild, limited or no symptoms and hence go unrecognized, and, depending on their contagiousness and numbers, can expose a far greater portion of the population to virus than would otherwise occur. Basic and clinical studies are necessary in order to correctly identify the basic characteristic of the virus and its potential damage. We study this basic problem identifying that the SARS-CoV-2 has a weekly multifractal structure. This result may have profound biological, medical and clinical implications at the level of basic approach as well as in order to establish its virulence in the actual clinical trials.

Materials and Methods

The image of SARS-CoV-2 is given in figure 1, provided by the European Research Council Magazine

https://erc.europa.eu/news-events/magazine/coronavirus-what-s-beyond-science-frontier



The details of the method have been exposed elsewhere and we will not repeat it here [Conte et al,2016] . We used MatLab software.

We remember here that $F_q(s)$ behaves, for large values of s, as a power law,

$$F_q(s) \infty s^{h(q)}$$

where $h(2)$ is the Hurst index h , and h(q)is the generalized Hurst index of the surface. $h(2)$ can be related to the fractal dimension D_f of the two-dimensional surface by means of the relationship $h = 3-D_f$.

The classical multifractal scaling exponents $\tau(q)$ are obtained by

$$\tau(q)=qh(q)-D$$

where *D* denotes the fractal dimension of the geometric support of the multifractal measure, for the two-dimensional measure, *D = 2*. The generalized multifractal dimensions is

$$D_q = \frac{\tau(q)}{q-1} = \frac{qh(q)-2}{q-1} \quad \text{with} \quad q \neq 1$$

In addition we have to characterize the multifractal surface via the singularity strength or Hölder exponent α and singularity spectrum $f(\alpha)$. They are related to $\tau(q)$ via a Legendre transform

$$\alpha(q) = \frac{d\tau(q)}{dq}$$

and

$$f(\alpha) = q\alpha(q) - \tau(q)$$

In addition we use the following indices of characterization:

a) $I = |h(q)-h(-q)|$(strength of multifractality)

expressing the degree of multifractality.

b) $\Delta\alpha = \alpha_{max} - \alpha_{min}$

c) $\Delta f = f(\alpha_{max})-f(\alpha_{min})$

for all *q* respectively.

The larger the value of $\Delta\alpha$ is, the smaller the even distribution of probability measure is, and the more roughness image texture surface will usually be expected. The latter is Hausdorff dimension of the measured object, which is used to measure the degree of irregularity.

d) To be able to make quantitative characterization of multifractal spectra, we usually use the procedure of fitting the spectrum to a quadratic function around the position of its maximum α_0

$$f(\alpha) = A(\alpha - \alpha_0)^2 + B(\alpha - \alpha_0) + C$$

The parameter B serves as an asymmetry parameter, which is zero for symmetric shapes, positive or negative for a left- or right-skewed (centered) shape, respectively.

e) To obtain an estimate of the range of possible fractal exponents, we may measure the width of the spectrum, extrapolating the fitted curve to zero. The width of the spectrum is $W = \alpha_1 - \alpha_2$ with $f(\alpha_1) = f(\alpha_2) = 0$

Results

As stated, we have examined images SARS-CoV-2.

First of all, let us verify that we have really obtained that the examined images represent a multifractal structure. The results relating *H(q)*, $\tau(q)$, α and $f(\alpha)$ are given in Figures 2-5, respectively

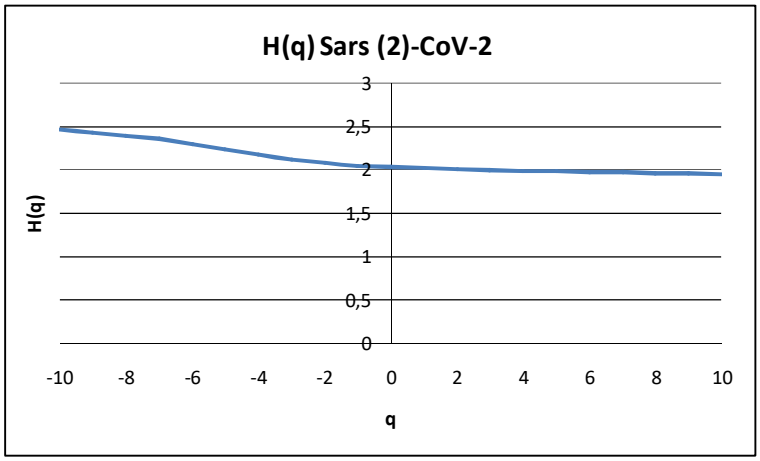


Figure 2. Results relating H(q) for the SARS-CoV-2.

As expected *H(q)* shows monotonically decreasing values as function of q.

$\tau(q)$ evidences its typical non linear dependence upon q

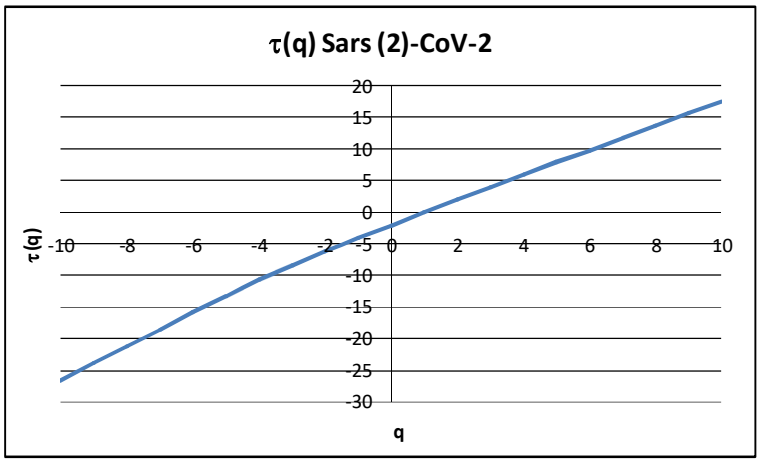


Figure 3. Typical non linear dependence of $\tau(q)$ from q for SARS-CoV-2

In Figure 4 we report the behavior of α for SARS-Cov-2

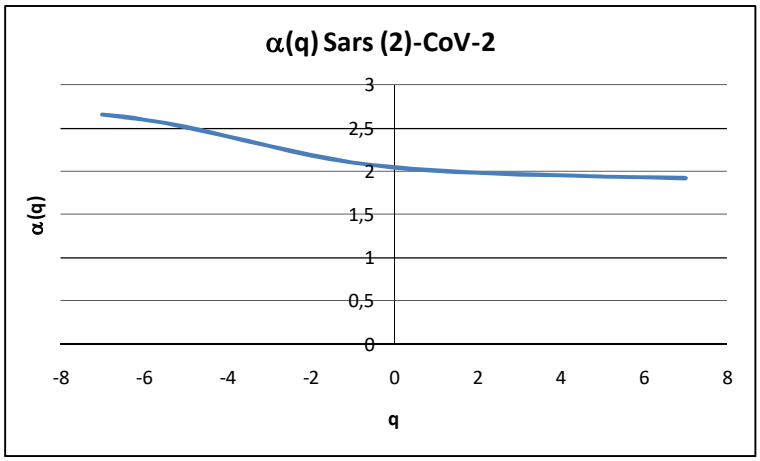


Figure 4. Typical Behavior of α for the SARS)-CoV-2

Finally, $f(\alpha)$ has the typical distribution of a multifractal spectrum.

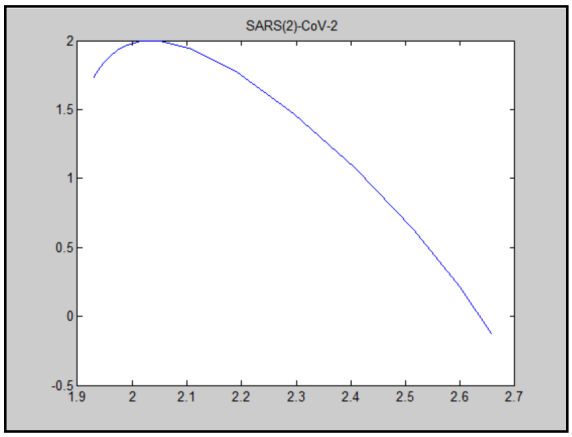


Figure 5. SARS-CoV-2: Typical distribution of the Singularity Spectrum, $f(\alpha)$

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In conclusion, we have reached evidence that SARS-CoV-2 is a virus having a multifractal structure.

The estimation of the Hurst exponent is H(2)=2.0056. The degree of multifractality *I,* the strength of multifractality, is 0.5067 for q ranging from -10 and +10 and 0.1890 for q= -4 and +4 , a weekly multifractal. We have also the results of $\Delta\alpha$ and of Δf . $\Delta\alpha$ results to be *0.7279* and Δf *-1.8481*. Also such results indicate that we are in presence of a virus structure having elevated roughness and irregularity .For the fitting of $f(\alpha)$, point d of the text, we find the following values for *A, B,* and *C*. *A= -5.3288, B=-6.6617 , C=-0.1726* with r^2= 0.9951 with a right-skewed centered shape.

Discussion and Conclusion

We have now to delineate the meaning of the study that we have performed.

We have performed an analysis to discover if SARS-CoV-2 delineates a multifractal structure and we have obtained confirmation that this infectious diseases may have multifractal signature. Healthy plants have been shown to have larger fractal dimensions than virus-infected ones. For an efficient photosynthesis, the fractal structure enables sufficient contact between the atmosphere and the chlorophyll (Escós et al., 1995).

The hypovirus-infected fungal strain displayed higher fractal dimension values, hence a lower hyphal density at the border of the colony, hence a lower growth rate, when compared to the virus-free strain. Therefore, the authors suggested that “Fractal dimension measurement is an effective quantitative tool for testing the effects of mycovirus infection” (Golinski et al., 2008).

The structural monofractility and/or multifractality of viruses and its influence on potential virulence is not yet clearly known. It has been suggested that the fatality of viruses depends on their higher fractal surface dimensions (He, 2008). The discovery of an existing multifractal behavior of SARS-CoV-2 substantially support**s** some basic and clinical indications which remain to be cleared at the basic as well as at the level of test in clinical applications. In fact, evaluating the area of spectrum of the multifractal SARS-CoV-2 may provide evidence about the invasive capacity of the virus. In addition, the discovery of such an existing multifractal behavior substantially support**s** the relevant indication of a novel epidemiologic actuarial trends and for basic bioresearch and their clinical applications starting with the basic idea that 'STRUCTURE IS FUNCTION'. Showing that SARS-CoV-2 is a multifractal , we reach a good evidence that SARS-CoV-2 is a virus having and performing its bio-attack to human tissues with a multifractal and peculiar distinctive structure ,adapted to more aggressive behavior: e.g. due to its pluri-uncinated capsidic spikes to bind itself to human-cell receptors more strongly than other known s pulmonary viruses. We have to consider menbranar surface of connectival lung mast cells. We think in fact pivotal for a more complete urinary-serosal diagnosis and for more wide-range ethiologic therapy, the role of so hyperactivated (from beta-Coronavirus-19) mastcell with their abnormal autoimmunitary fast and strong response i.e a) massive degranulation b) productions of inflammatory (from COx ano LOx) PGs and LTs and ILs-CKs interleukins chemiokins c) growth factor to induce T and B maturation and response (with other hyperflogistic ILs) and their diapedesis d) vasoactive chemotactic and proteases to do simpler T and B

diapedesis and migration at the lung site of viral infection . These are all effects due to alterations of non-canonical Wtn-signaling and SLAM-modulation and other epigenetic and trascriptional pathophysiologic disruptive pathways that lead to the more acute lung interstitial pathology and to the consequent Sars.

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