Nature of Spreading of COVID-19 in Various Countries: Physical Model in Society Framework

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Abstract

As per World Health Organization (WHO) record, cases of novel coronavirus (COVID-19) in Wuhan City in Hubei province of China have been recorded at the end of 2019. Later, several lakhs of positive cases and more than one lakh deaths have been reported due to COVID-19 across the globe. It is therefore important to know a right direction on how to collect and execute data from other countries and to provide futuristic approach using mathematical model. Suitable physical model has been considered as "data analysis tool" of "confirmed cases" in the society framework to shed some light on the nature of COVID-19 spreading across the world.

Keywords: COVID-19 Data; Almond-West Model in Society Framework; Fractional power law exponent (n); Scaling Approach; lower and intermediate spreading and Percolation

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1. Introduction:

In recent moments, real time data [1] exhibit that coronavirus disease 2019 (COVID-19) has spread rapidly throughout the world as a pandemic nature. With a view to spreading awareness of COVID-19 among all types of people around the globe, initiatives being undertaken in various ways [2]. Italy, Spain, United States and many more countries have already witnessed in its pandemic nature in overburdening the healthcare system [1] and increasing the mortality rate [1]. Recent work [3] on COVID-19 epidemic processes has given a direction on how to collect and execute data from other countries and to provide futuristic approach using a simple mathematical model. In this regard, data analysis [4, 5] plays an important role to provide a right direction, not only for academic interest but also for application point of view. But this unique approach on COVIS-19 data analysis is still unexplored.

Recent research on social networks [6] plays a key role in exploring the dynamical nature of various systems (equilibrium and non-equilibrium) and in describing a right path for taking corrective measure in particular. In particular, suitable physical models [7, 8] have been considered as "data analysis tool" of heterogeneous disordered solids. It is noted that these models [7, 8] usually provide fruitful results, which are very close to reality. To shed some light on the nature of COVID-19 data [1] in various countries, some physical models [7, 8] have been employed here, whose outcomes are expected to be very helpful to develop solutions to combat this disease.

2. Results and Discussion:

The experimental AC conductivity data of heterogeneous disordered solids could be well explained using Almond-West model [7, 8]. Our society structure could be similar to heterogeneous disordered solid system. So my attempt is to interpret COVID-19 data (confirmed cases) of few countries [1] on the basis of that model [7, 8] in the society framework, which can be depicted as

$$\sigma = \sigma_0 [1 + (\omega / \omega_H)^n] \quad (1)$$

In this model, ω is the "number of days" and σ is considered to be the total number of confirmed cases which is the sum of the number of constant cases (σ_0), crossover days (ω_H) and a fractional power law exponent (n). This model could be employed to get sufficient information on the nature of COVID-19 spreading throughout the countries exactly in the same way as Almond-West model [7, 8] played in ion-dynamics phenomena of disordered solids. The term, crossover days (ω_H) is supposed to be the critical time interval above which σ (total number of confirmed cases) may be ascribed due to correlated dynamics of confirmed cases that has hoped away to return its original position. Here, I have collected real time COVID-19 data of confirmed cases [1] from WHO portal till 19th April, 2020. Fig.1 represents the variation of confirmed cases with time (number of days) in log scale 12 countries around the globe. In lower region of "number of days" scale, flat nature of "confirmed cases" has been observed, which corresponds to the "constant cases". The reason of this type of flat nature of "confirmed cases" in the lower "number of days" regime may be due to the diffusion of confirmed cases of COVID-19 on longer timescales and longer length scales. At higher "number of days", the confirmed cases of COVID-19 shows dispersion and follows a power law nature, indicating a non-random, correlated and sub-diffusive nature of spreading this disease. It is remarkable from Fig. 1 that COVID-19 data for USA increases sharply and COVID-19 data for China shows saturation at higher "number of days". The real time COVID-19 data in Fig. 1 has been well-fitted by Eq. (1). The values of σ_0, ω_H and n have been computed from this fitting and are presented in Table 1. In this fitting, only saturation regime data for China is excluded as it is dissimilar to other country-data. In ion-dynamics of disordered solids [9], n is associated with dimensionality of ion motion. In the present society framework, the nature of COVID-19 spreading may be dependent on three set of n values as presented in Table1. n < 1.5 may indicate lower spreading nature of COVID-19 and it happens in Slovenia. On the other hand, 1.5 < n < 3.6 indicates intermediate spreading nature of COVID-19 and it happens in all mentioned countries except USA, China, Pakistan and Bangladesh as n > 3.6 is applicable for them. Different ranges of "n" may be associated with some essential local parameters. Additionally, scaling approach of AC conductivity model [8] has been adopted in the society framework to interpret the values of some essential local parameters. Effort has been given to plot scaling [8] of real time COVID-19 data as shown in Fig. 2. Proper scaling is not observed in Fig. 2, but the nature of scaling data of countries except USA, China, Pakistan, Bangladesh and Slovenia are found to be similar. The tendency of such similar nature scaling data may impel us to predict a perfect overlap in next couple of weak. A perfect scaling [8] in the society framework should indicate that the spreading of COVID-19 is independent of population or population density of those set of countries (essential local parameters) mentioned earlier. So, it may be predicted right now that this set of countries should contain, at least, similar nature of COVID-19 spreading. On the other hand, spreading of COVID-19 in 5 other countries (mentioned earlier) is of percolation type. Nature of n and ω_H also validate this scaling approach.

3. Conclusion:

Almond-West model for disordered solids has been adopted in the society framework as "data analysis tool" of "confirmed cases" to interpret the nature of COVID-19 spreading across the world. Fractional power law exponent (n) has impelled us to conclude that intermediate spreading nature of COVID-19 has been confirmed in all mentioned countries except USA, China, Pakistan and Bangladesh. Scaling approach indicates that COVID-19 spreading in these 7 countries is roughly independent of some local essential parameters like population or population density and it shows percolation type for other 5 countries mentioned earlier. This data analysis is highly expected to be helpful for developing the way of COVID-19 issues across the globe.

References:

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Figure Captions:

Fig. 1: Graphical Nature of "Confirmed Cases" versus "number of days" in log scale for 12 countries data as per WHO portal up to 19th April, 2020. Solid lines indicate best fitted curves using Eq. (1).

Fig. 2: Scaling of "Confirmed Cases" versus "number of days" for 12 countries data as per WHO portal up to 19th April, 2020.

Table-1: Different parameters, obtained from fitting of COVID-19 data from WHO portal using Eq. (1).

Country	Constant Cases (± 0.1)	Crossover Days (± 0.1)	Dimensionality (± 0.01)
USA	55	10	5.7
Iran	1	1	2.8
Slovenia	16	4.2	3.6
China	36.4	6.7	4.7
France	91.4	2.6	2.5
Spain	41.8	2.6	2.9
Italy	1402	2.7	1.7
India	3.43	4.6	3.4
Pakistan	3.5	6.6	3.9
Bangladesh	3.1	11.2	4.6
United Kingdom	37.55	4.5	3.35

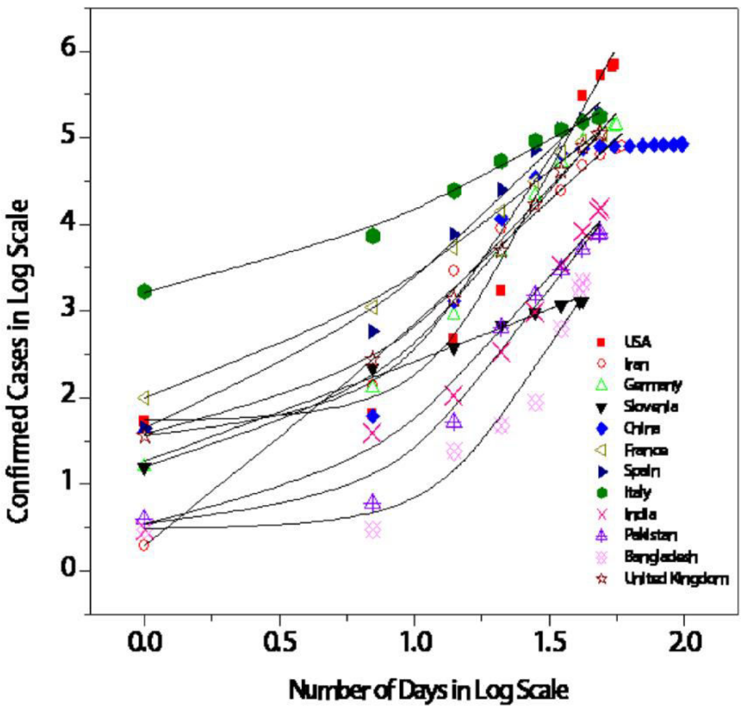
Confirmed Cases in Log Scale
Number of Days in Log Scale
USA
Iran
Germany
Slovenia
China
France
Spain
Italy
India
Pakistan
Bangladesh
United Kingdom

Fig. 1

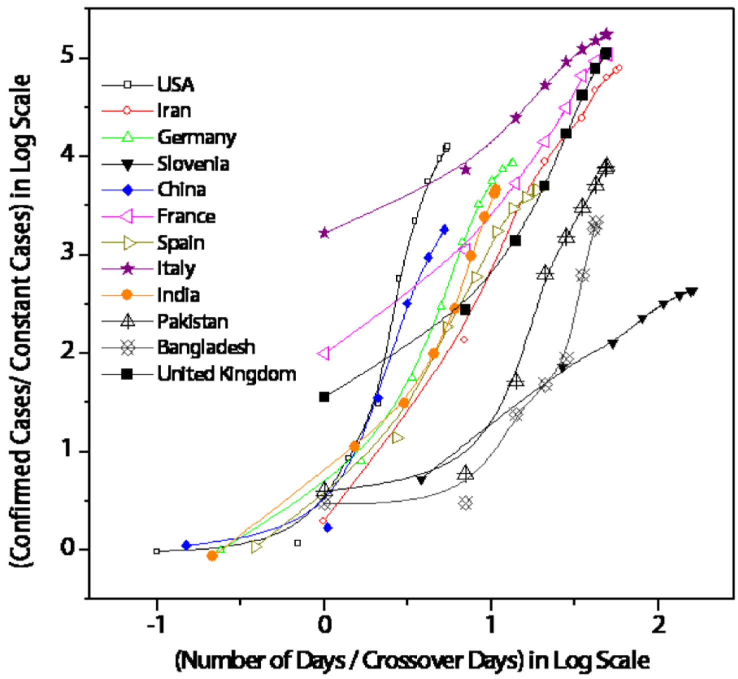
(Confirmed Cases/ Constant Cases) in Log Scale
(Number of Days / Crossover Days) in Log Scale
USA
Iran
Germany
Slovenia
China
France
Spain
Italy
India
Pakistan
Bangladesh
United Kingdom

Fig. 2