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Modeling statistics and kinetics of the natural aggregation structures and processes with the solution of generalized logistic equation

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Abstract

The generalized logistic equation is proposed to model kinetics and statistics of natural processes such as earthquakes, forest fires, floods, landslides, and many others. This equation has the form

$$\frac{dN(A)}{dA} = s \cdot (1 - N(A)) \cdot N(A)^q \cdot A^{-\alpha},$$

$q>0$ and $A>0$ is the size of an element of a structure, and $\alpha \geq 0$. The equation contains two exponents α and q taking into account two important properties of elements of a system: their fractal geometry, and their ability to interact either to enhance or to damp the process of aggregation. The function $N(A)$ can be understood as an approximation to the number of elements the size of which is less than A. The function $dN(A)/dA$ where $N(A)$ is the general solution of this equation for q=1 is a product of an increasing bounded function and power-law function with stretched exponential cut-off. The relation with Tsallis non-extensive statistics is demonstrated by solving the generalized logistic equation for q>0. In the case 0<q<1 the equation models super-additive, and the case q>1 it models sub-additive structures. The Gutenberg-Richter

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