STUDY OF THE ASTEROIDS AND COMETARY STRUCTURE USING FRACTAL ANALYSIS

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Introduction: Currently, the basic methods of analyzing processes in complex systems are statistical ones [1]. They have restrictions of probabilistic and statistical approaches, since not every process and not every result (form and structure of system) is of probabilistic nature. In contrast to this, fractal analysis allows studying structure of complex objects taking into account their qualitative specificity. Determination of fractal dimension allows studying both the structure itself and the connection between the structure and processes of its formation. The problem of developing methods of determining fractal structures of complex objects is relevant in this regard. Thus, anomalies of meteoroid' physical surface are multi-parametric systems whose analysis should be conducted using the methods of physics of complex systems, and fractal analysis is one of them [2]. In this paper, fractal structures of Vesta asteroid were studied on the basis of Hubble Space Telescop data.

Methods: The models of Vesta' physical surface are of complex structure, and to study them the methods of multi-parametric analysis are required. Such models are fractal structures. Thus, the best method of analyzing such systems is fractal geometry. Significant differences between fractal dimensions for the Vesta' surface model and its real physical values show that there is some complex distribution of model structure in space. In this paper, while constructing a model of fractal object, the Weierstrass-Mandelbrot fractal function was used. On the one hand, complex physical systems cannot be described as a single fractal and represent multifractals consisting of a set of interconnected fractals of their own dimensions. On the other hand, in a fractal model, each part of it repeats the entire model on structure and does not change at various scales, i.e. it is recursive. Use of multifractal analysis allows studying a system as a spectrum of fractal dimensions. Such method provides high accuracy when describing complex fractal structures by investigating local areas. In the present paper, for determining and analyzing fractal dimensions the Minkowski mathematical algorithm, which is a simplified option of Hausdorff-Besicovitch dimension and provides high reliability and accuracy, was used. Using harmonic analysis of expansion in spherical functions of the topographical data received from boards of Hubble Space Telescop, a topographic model of Vesta asteroid was constructed. As a model describing the Vesta's relief we use expansion of altitude function in a series of spherical harmonics in the form of regression. Unfortunately, the series is slowly convergent. For instance, to describe the relief's details changing through 1 degree the order of expansion of about 180 is required, which causes the necessity of estimating $(180+1)^2$ coefficients (amplitudes) of expansion. Practically, dimension of the model and therefore the order n should be chosen based on the amount of objects approximately evenly distributed over the sphere. The number of them should exceed the number of estimated objects from 5 to 15 times. In terms of the regression modeling approach, we solved the overdetermined system for various sources of hypsometric information. Along with the usual stages (postulating the model and the amplitudes Cnm, Snm estimation), the approach involves the application of a number of quality statistics including the external measures.

Results: As result, the topographic model of Vesta asteroid was cut by planes on meridians with 17 longitudes in order to create macroprofiles of the planet's surface. For each cut, fractal dimensions were calculated. If N is the number of covers in the area investigated, then the division into covers starts with the value of 24, since the number of covers is supposed to be integer. . Considering the fact that the more significantly topological dimensions of a structure differ from fractal ones, the more complex formation of the system is, the similarity of topographic formations on Vesta is sufficiently defined. The next stage is the determination of fractal dimensions in longitude. To conduct this, cuts of Vesta models by Vesta' meridians in certain Vesta' longitudes within 0 – 350 degrees with a step of 25 degrees were made. It should only be noted that topographic fractal dimensions behave evenly. For the topographical data the variations of fractal dimensions change between 0.85 and 1.10.

Conclusions: It should be noted that the method of fractal analysis allows for the introduction of independent estimates of Vesta asteroid macrostructure, which leads to the new approaches to interpreting physical processes taking place on Vesta. The further use of fractal comparative analysis when processing the data of space observations allows obtaining the important results that will help to solve many problems of space investigations.

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