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RECOMMENDATIONS FOR MODELING FRAGMENTS DISTRIBUTION BASED ON EMPIRICAL STUDY OF METEORITES

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ABSTRACT

This work is concerned with the study of optimal statistical description for size distribution of meteorite samples. Such description can hint on initial projectile properties and physical parameters responsible for underlying fragmentation processes. If recovered meteorite collection pretend to be complete, number of corresponding fragments is statistically sufficient, and they have been weighted with good precision, one can propose a reliable model well applicable to more general cases when the set of input parameters is no so complete. We have found that the experimental plots for number of meteorites have clearly distinguishable shape, which can be fitted by several distributions, including normal, logistical and other continuous sigmoid cumulative functions like Weibull.

In order to confirm or reject goodness of fit for the selected theoretical distributions we use Pearson's and Fisher's chi-squared tests as well as G-test. For the log-normal distribution we also apply modified Kolmogorov–Smirnov test. Sometimes the empirical cumulative distribution function is found to be not descriptive enough. In this case it is plausible to plot and inspect the corresponding histogram. Additional local maxima present on the left and right tails provide insight on the possible multimodal nature of underlying theoretical distribution. We found that bimodal distributions are often more suitable than their unimodal counterparts. Another approach to statistical investigation deals with the cumulative number of fragments instead of their mass fraction. We assume both approaches useful and consider a number of known statistical functions, including the log-normal distribution [1], the Waybill distribution, the linear exponential statistics, known as Graddy distribution [2,3], and the Gilvarry distribution [4,5].

All above-mentioned distribution laws are relevant to the cause. For example, the Weibull distribution provides successful empirical description for lifetimes of objects, fatigue data and the size of particles generated by grinding, milling and crushing operations. The Gilvarry distribution is proposed for the same purpose, however, it is defined as the probability density instead of CDF. These distributions are applied to the sample resulting in the goodness-of-fit values.

We have confirmed that the Gilvarry distribution has one special aspect in comparison with other considered distributions. As stated in [6] Gilvarry theory overestimates the number of small lightweight fragments. Both Grady and Gilvarry distributions are correct under assumption of nearly-instant singular breakup [6, 7]. If material is exposed to multiple successive fragmentation events, then the above-mentioned distribution laws are no longer applicable. However there is a recent development of the fragmentation theory [8], which can be incorporated.

The considered distributions provide us additional valuable information about the properties of the projectile. Thus, in certain cases, assuming bimodal lognormal, bimodal Grady or bimodal sequential fragments distributions we have found a number of fragmentational points taken place. Such conclusion hints on a primary singular prefragmentation of the body and the consequent atmospheric entry of independent fragments with respective residual masses.

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