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Talk Invited Invited Talk

Possible origins of the power-law distributions

G. Wilk[1*], Z. Włodarczyk[2]

[1] National Centre for Nuclear Research, Hoża 69, 00-681 Warsaw, Poland
[2] Institute of Physics, Jan Kochanowski University, Świętokrzyska 15, 25-406 Kielce, Poland
[*] Electronic Address: wilk@fuw.edu.pl

The possible origins of power-law distributions are presented as seen from the perspective of high energy multiparticle production processes (summarized in [1, 2]). In these processes one has usually encountered exponential distributions of different sorts, $f(x) \propto \exp(-x/x_0)$. However, recently one observes that almost all of them develop for large x as power-like distribution, $f(x) \propto x^{-\gamma}$. Tsallis distribution, $f_q(x) \propto [1-(1-q)x/x_0]^{1/(1-q)} = \exp_q(-x/x_0)$, seems to be the most natural choice allowing for description of the whole range of x with a one new parameter, q. We discuss origin of such behavior as seen and understood from our experience with describing multiparticle production data. In particular we discuss:

- Fluctuations of scale parameter x_0 in exponential distribution (superstatistics) (resulting in $exp_q(x)$ distributions with $q > 1$).
- The use of conditional probability resulting in $q < 1$; as special example we consider thermodynamic system containing small number of particles.
- The use of order statistics (understood as distribution of the minimal value of the observable of interest).
- The use of stochastic network approach ((in which the scale parameter depends on variable under consideration). In this case one can show, for example, that

$$\exp_q(-x) = \prod_{k=1}^{\infty} \exp\left[-x^k(1-q)^{k-1}/k\right].$$

In addition, derivations of Tsallis distribution in statistical physics (where for small system $q \leq 1$) are also discussed. The possibility of obtaining Tsallis distribution from Shannon entropy are mentioned as well. Finally, we demonstrate the possibility to check in high energy multiparticle production processes the apparent duality between q parameter (used in Tsallis distributions applied to fit some experimental data, f_q) and $2-q$ parameter resulting from the corresponding Tsallis entropy, S_{2-q} (used to estimate, in the same reactions, multiplicities of produced particles).

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[1] G. Wilk and Z. Włodarczyk, *Consequences of temperature fluctuations in observables measured in high energy collisions*, arXiv:1203.4452v2 [hep-ph], to be published in special issue of *Eur. Phys. J.* **A** (2012).

[2] G. Wilk and Z. Włodarczyk, *Eur. Phys. J.* **A40**, 299 (2009).