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z-Scaling and Search for Signatures of Phase Transition in Nuclear Matter

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The concepts of "scaling" and "universality" have been developed to study critical phenomena. Scaling implies that systems near a critical point (CP) exhibit self-similarity and are invariant with respect to scale transformations. The universality of their behavior lies in the fact that vastly different systems behave in a similar way near the respective CP.

We present some results of analysis of hadron production in $p + p$ and $A + A$ collisions obtained in the framework of z-scaling in searching for signatures of a phase transition in nuclear matter. This approach is one of the methods allowing systematic analysis of experimental data on inclusive cross sections over a wide range of the collision energies, multiplicity densities, transverse momenta, and angles of various particles. The concept of the z-scaling is based on the principles of self-similarity, locality and fractality reflecting general features of particle interactions. The self-similarity variable z is a function of the momentum fractions x_1 and x_2 of the colliding objects carried by interacting hadron constituents and depends on the fractions y_a and y_b of the scattered and recoil constituents carried by the inclusive particle and its recoil counterpart. The scaling function $\psi(z)$ is expressed via inclusive cross-section, multiplicity density and three model parameters. Structure of the colliding objects and fragmentation processes is characterized by the structural and fragmentation fractal dimensions δ and ϵ, respectively. The produced medium is described by a "specific heat" c. The function $\psi(z)$ reveals energy, multiplicity, angular and flavor independence found in analyses of inclusive spectra measured at the ISR, SPS, Tevatron, RHIC and LHC. A microscopic scenario of hadron production in terms of constituent momentum fractions and recoil mass of produced system is developed. The constituent energy loss as a function of energy and centrality of collision and transverse momentum of inclusive particle is estimated in the z-scaling approach. Discontinuity of the model parameters - the fractal and fragmentation dimensions and "heat capacity" - are discussed from the point of view of the search for a phase transitions in the nuclear matter.

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Primary authors: Dr ZBOROVSKY, Imrich (Nuclear Physics Institute); Prof. TOKAREV, Mikhail (Joint Institute for Nuclear Research)

Presenter: Prof. TOKAREV, Mikhail (Joint Institute for Nuclear Research)

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