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Mathematical aspects of the nuclear glory phenomenon: from backward focusing to Chebyshev polynomials

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The angular dependence of the cumulative particles production off nuclei near the kinematical boundary for multistep process is defined by characteristic polynomials in angular variables, describing spatial momenta of the particles in intermediate states [1, 2]. Physical argumentation, exploring the small phase space method, leads to the appearance of equations for these polynomials in $cos(\theta/N)$, where θ is the polar angle defining the momentum of final (cumulative) particle, the integer N being the multiplicity of the process (the number of interactions). It is shown explicitly how these equations aappear, the recurrent relations between polynomials with different N are obtained. Factorization properties of characteristic polynomials found in our previous work [3] are extended, and their connection with known in mathematics Chebyshev polynomials of 2-d kind [4, 5] is established. As a result, differential cross section of the cumulative particle production has characteristic behaviour $d\sigma \sim 1/\sqrt{\pi - \theta}$ near the strictly backward direction ($\theta = \pi$, the backward focusing effect). Such behaviour takes place for any multiplicity of the interaction, beginning with $n = 3$, elastic or inelastic (with resonance excitations in intermediate states) and can be called the nuclear glory phenomenon, or 'Buddha's light' of cumulative particles.

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