Research
Journal of
Physics
RJPHY

OPEN ACCESS

Executive Summary

Tsallis Thermodynamics: Systematic Calculations

Andrea Ricky

In high-energy collision physics, power-law distributions have frequently been employed to describe particle yields. In the transverse momentum (*p*T) space, it has been observed that the pions, kaons, protons, and other hadrons that were produced in these collision events follow a power-law distribution. It is also linked to Tsallis statistical mechanics, a statistical approach that has been utilized for a while to deal with fractal structure, tiny system size, long-range correlation, and fluctuating media. Later, it was determined that the distribution is the exact zeroth-order approximation of the *Tsallis*-like transverse momentum distribution in the Tsallis-2 prescription based on the definition of the *Tsallis* entropy. The primary goal of this paper was to present an overview of analytical findings about the *Tsallis* thermodynamics, which have been the focus of numerous investigations in the area of high-energy collisions.

The equation was generated for the Pressure of a Gas of Bosons following the Tsallis Distribution. They were further generated as an equation, *Rescaling the Integration Variable, Infinite Summation, Contour Integral Representation, Wrapping Contour Clockwise, and Analytic Continuation*. Each of them has different numerical results. Throughout Professor Jean Cleymans' trip to India in 2015, there was a resurgence of interest in this endeavour.

The finding that Taylor's series expansion may be used to write the Tsallis-like distributions in the rising order of $(q - 1)^n$, $n \varepsilon Z \geq (Z \geq$ (where Z denotes the set of non-negative integers) served as the inspiration for this endeavour. The Tsallis thermodynamic variables for an ideal gas of large particles were examined in a joint publication. The Tsallis distribution was truncated at O (q^2) ^2, which was ultimately discovered to be a limitation of the results. It was a breakthrough when Cleymans demonstrated that the computations for the massless situation could be carried out analytically.

In a similar research paper, it was discovered that both the massless case and the large case preserve the intriguing features (such poles) that were overlooked in the Taylor approximation calculations. The existing information is expanded to the quantum realm in this study, and a method for calculating analytical equations for the quantum Tsallis thermodynamic variables is suggested. Isotropic momentum distributions are considered. It would be appropriate to make a few observations regarding the comparison between numerical results and outcomes derived from analytical formulae. Researchers change the equation's numerical values to assess this and compare the outcome to the integral's numerical value.

In conclusion, the authors gave a succinct overview of research on Tsallis thermodynamics that may be crucial for future investigations into the quark-gluon plasma and other systems that exhibit fluctuation and long-range correlation. Researchers compute the quantum thermodynamic variables after analyzing the findings for the classical case in the massless limit and classical particles of any mass.

Journal Reference

Hussein, A.; Bhattacharyya, T., 2022. Analytical Calculations of the Quantum Tsallis Thermodynamic Variables. Physics 2022, 4, 800–811.

KEYWORDS

Tsallis statistics; Tsallis thermodynamics; thermodynamic variables; integral representation