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# Sound waves in hadronic matter

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## Content

The large transverse momentum distributions of particles observed in all LHC experiments exhibit a quasi-power-like behavior following the two-parameter Tsallis distribution with a scale factor T and nonextensivity q. Such distributions can originate from different dynamical mechanisms. However, looking at the ratios of the measured cross-sections to their phenomenological power-like fits, R = f_{data}(p_T)/f _{fit}(p_T), one discovers some log-periodic oscillations in R [1]. This is a rather subtle effect, nevertheless, it shows itself in all experiments, at all energies (provided that the range of transverse momenta observed is large enough) and it cannot be erased by any reasonable change of fitting parameters. It is therefore unlikely that these oscillations represent some artifacts of the measurement process. They become stronger in reactions with nuclei where they grow with increasing centrality of the collision [2]. Such oscillations are seen in all branches of physics whenever one deals with power-like distributions. They are usually attributed to a discrete scale invariance (connected with a possible fractal structure of the process under consideration) and are described by introducing a complex power index [1] (the other possibility, based on the two component (soft+hard) model of multiparticle production processes, does not show continuation of these oscillations, the beginning of which is seen in data [2]). However, one can also describe them by allowing for some specific log-periodic oscillations of the scale parameter T [3] (both approaches are numerically equivalent). This could be, for example, connected with propagation of sound waves in hadronic matter [4]. In this talk we present study of the propagation of such sound waves by considering the propagation of perturbations in the temperature and demonstrate that they generate log-periodic waves. Using their Fourier transform we can gain a new, unnoticed so far, information on the space-time structure of the production proces [5]. In particular, we have found that the Fourier transform picture of the log-periodically oscillating T represents some log-periodic acoustic wave forming in the source and that the corresponding wave equation has self-similar solutions of the second kind connected with the so called intermediate asymptotic (observed in phenomena which do not depend on the initial conditions because sufficient time has already passed, although the system considered is still out of equilibrium). It turns out that both in p+p and Pb+Pb one deals with an inhomogeneous medium with both the density and the velocity of sound depending on the position in the way which seems to be supported by experimental results. Possible connection with fluctuation of multiplicity is also discussed [5]. [1] G.Wilk, Z.Wlodarczyk, Physica A413 (2014) 53. [2] M.Rybczynski, G.Wilk , Z.Wlodarczyk, EPJ Web Conf. 90 (2015) 1002. [3] G.Wilk, Z.Wlodarczyk, Chaos Solit. Frac. 81(2015) 487. [4] D.A. Fogaca, L.G. Ferreira Filho, F.S. Navarra, Nucl.Phys. A819 (2009) 150; T.Bhattacharyya, P.Garg, R.Sahoo, P.Samantray, Eur.Phys.J. A52 (2016) 283. [5] G.Wilk, Z.Wlodarczyk, Temperature oscillations and sound waves in hadronic matter, ArXiv: 1701.06401.

## Session

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