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COLLECTIVE EFFECTS IN STRONG INTERACTION PROCESSES: EXPERIMENTAL HIGHLIGHTS

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Collective effects are reviewed for collisions of various systems – from proton-proton to heavy ion – in wide energy range. Collectivity is one of the crucially important and most essential fea-tures in reactions with subatomic particles due to strong interaction. As consequence, a study of collective behavior in multiparticle production processes provides one of the most sensitive and promising probes for detailed investigation of basis features of strong interaction. Recent exper-imental results obtained at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC) are considered. Hadron jets being one of the most famous collective effects in strong interaction are intensively study in various collisions [1]. In proton-proton interactions such studies devote to the better understanding of hadronization, precise determination of strong coupling constant, parameters of top quark and its production [2], verification of the predictions of Quantum Chromodynamics (QCD) in events with different topology, search for the physics beyond of Standard Model (SM), in particular, within Effective Field Theory (EFT) approach [3, 4] for top quark sector [2, 5–8]. Investigations of different nuclear collisions focus on exploration of the phase diagram of strongly interacting matter, particularly, on detailed study of properties of quark-gluon matter under extreme conditions considered presently as the strongly coupled quark-gluon plasma (sQGP). Results at RHIC [9] and LHC [10–12] energies provide important information about event shapes as well as transport and thermodynamics properties of the hot medium for various flavors. Measurements show clearly the collective behavior of heavy quarks in nucleus-nucleus interactions. Studies of jets in strongly interacting environment via correlations of different particles including heavy hadrons lead to new constraints for energy loss models, allow the search of the new physics signatures with heavy-ion collisions. First results have been obtained at the LHC for massive gauge bosons and antitop-top pair production in proton-nuclear and heavy ion collisions at multi-TeV energies. The surprising sQGP-like collectivity has been observed in collision systems smaller than even moderate nuclei, especially, at the LHC energies. Experimental results obtained for discrete symmetries of QCD at finite temperatures confirm indirectly the topologically non-trivial structure of QCD vacuum [13–17]. Such investigations are important for the decision of the problems of CP invariance of the strong interaction and baryon asymmetry of Universe. In the soft sector of the strong interaction one can expect some novel mechanisms for multiparticle production due to collectivity in very high energy nuclear collisions, in particular, increasing of coherent particle production. The investigation of Bose–Einstein condensation (BEC) will shed new light on the nature of superfluidity of strongly interacting matter which is the one of the fundamental properties of sQGP, on the possibility of laser-like regime for pion production at very high energies [18]. Studies of collective effects in strong interaction processes provide new important results for relativistic astrophysics, cosmology and cosmic ray physics. The recent measurements of femtoscopic correlations allow, in particular, the indirect estimations for parameters of hyperon–nucleon potentials. The new constrains for these potentials will make model predictions more reliably for compact astrophysical objects [19–23]. Studying the possible BEC effect on the pion yield at very high energies [24] can be considered one of perspective research directions for better understanding of the nature of the muon puzzle in ultra-high energy cosmic ray (UHECR) measurements [25–27]. Therefore collective effects in strong interaction processes studied on accelerator facilities are important for various fields of fundamental physics and investigation of the effects has large interdisciplinary value.

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