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# Study of light nuclei and strange baryon production in proton–proton and Pb–Pb collisions with ALICE

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A comprehensive description of the mechanisms underlying particle production in the cool-down of physics systems characterized by extreme energy density and temperature is still an open point. An outstanding example of such a highly energetic process is supplied by the high energy hadronic collisions provided by the Large Hadron Collider (LHC) at CERN. An abundant production of light flavor particles, made up of u, d and s quarks, is observed in the proton-proton (pp), proton-lead (p–Pb), xenon-xenon (Xe–Xe) and lead-lead (Pb–Pb) collisions delivered by the LHC in the years between 2015 and 2018 (known as Run2 phase). The center of mass energies of such collisions ranges between 900 GeV and 13 TeV. ALICE (A Large Ion Collider Experiment) was specifically designed to study ultra-relativistic heavy-ion collisions provided by the LHC. In these collisions, thanks to the unprecedented conditions of high energy density and temperature reached, a thermodynamic transition from standard hadronic matter to a deconfined phase is foreseen. Such an exotic state of hadronic matter is called Quark-Gluon Plasma (QGP) as partons, i.e. quarks and gluons, are not confined into hadrons. The conditions created with heavy-ion collisions at the LHC characterized the early Universe in its first microseconds and it is believed to be currently present in massive and dense objects as neutron stars. Due to the recent experimental observation of unexpected behaviors in the kinematics and dynamics of particle production in small collision systems (pp and p–Pb collisions), which resemble those expected when a deconfined phase is reached, new interest was prompted in the study of small colliding system features. Among all the light flavor particle species, light nuclei and strange particles are two outstanding examples of the large variety of measurements which can be performed to characterize the processes underlying high energy hadronic collisions, ranging from small to large collision systems.

The first part of this thesis work is devoted to the measurement of the production of light nuclei and antinuclei, whose formation in the early universe happened on time scales between 10 and 180 seconds, well before fusion in stars started to build-up heavier nuclei states. The measurement of the production spectra of protons, deuterons, helions and their antimatter counterparts is presented for pp collisions at $\sqrt{s} = 5.02$ TeV. Relying on this measurement, the coalescence parameter $B_{\mathrm{A}}$, which is related to the probability to form a nucleus via a coalescence process starting from nucleons, and the ratio between the integrated production yields of nuclei and protons are evaluated.

The second part consists of the measurement of multi-strange particles, the $\Xi$ and $\Omega$ baryons, in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV. The presence of strange and multi-strange objects into the core of neutron stars is currently debated and could give an explanation for the existence of neutron stars with masses larger than twice the solar mass, which have been observed but are at present not accounted for by the most up-to-date equation of states. The production spectra of multi-strange baryons are presented and the ratio between their integrated yields and the production yields of pions are evaluated.

Both the results from light nuclei and multi-strange particles are reported as a function of the average charged particle multiplicity of the collision, and are compared to previous measurements performed by the ALICE experiment across different collision systems and to the up-to-date theoretical predictions. This comparison proves to be a useful tool to shed light on the dependence of the light flavor particle production mechanisms on the size of the hadronizing system only, without any dependence on the type of collision system or center of mass energy.

The results from the nuclei analysis have been approved by the ALICE collaboration and have been published, while those from multi-strange particles will be submitted for publication soon.