Nuclear Physics at the LHC: a unique doorway to investigate the hyperon-puzzle in neutron stars and to enable the search for dark matter in cosmic rays

Nuclear Physics studies at the LHC have recently demonstrated a wide breadth of possible applications to astrophysics. On the one hand, hyperon-nucleon and hyperon-hyperon interactions can finally be investigated with high precision and these results are fundamental to study the equation of state of neutron stars. On the other hand, the physics of light anti- and hyper-nuclei (e.g. anti-deuteron, anti-3He or anti-hyper-triton) have recently sparked a large interest in the communities of astroparticle physics because of its connection to dark matter searches in cosmic rays.

- Future results provided by the NICE spectrometer on the mass and radius of neutron stars and upcoming gravitational wave events will need a test from the nuclear physics counterpart to validate the many scenarios about the content of neutron stars.

- The novel results on hyperon-nucleon and hyperon-hyperon interactions provided by correlation studies at the LHC by ALICE are key to compute more realistic equation of state for neutron stars containing hadrons with strange content. This is mandatory to solve the current hyperon puzzle and clarify on the content of neutron stars.

- Space-borne experiments like AMS look for anti-nuclei that are produced in the annihilation of dark matter particles. The background rates in these searches are constrained by collider-based experiments like ALICE at the LHC.

- The production rates of light hyper-nuclei in heavy-ion and high energy collisions crucially depend on the extended wave-functions of these objects, thus closely linking the physics of nuclear structure and the hyperon-nucleon potentials with heavy-ion physics.

- Proton-Deutron, Hyperon-proton and hyperon-deuteron correlations at the LHC can be employed to pin down the formation mechanism of anti- and hyper-nuclei at the LHC. Indeed, correlations are unique probes of the strong interaction among the constituents of anti- and hyper-nuclei and can provide quantitative information on the nuclei wave-functions.