A study on the gluon saturation influence on the development of atmospheric air showers

H. M. SOARES[1] AND V. DE SOUZA[1]

[1] *Instituto de Física de São Carlos, Universidade de São Paulo*

hendrik.soares@gmail.com

Abstract: The determination of the composition of ultra high energy cosmic rays is an open question due to natural fluctuations of the first interaction and unknown high energy cross sections. The most traditional method to infer the mass composition at the highest energies is the elongation rate. In this method, the measured depth in which the shower reaches its maximum is compared to simulation predictions such as that the interpretation of the data depends on the simulation results. Other studies [1] have calculated the effect of systematics modifications in the hadronic interaction properties in the development of extensive air showers and, consequently, leading to different interpretations of the cosmic ray composition. In high energy limit ($E > 10^{18}$ eV), gluon saturation may occur in the nuclear surface region, so the cross section proton-proton and proton-nucleus increases more rapidly with incident energy than Glauber theory. The cross section rise with energy is related to the probability distribution function of scattering centers which is larger in gluon saturation models. In this work we analyze the cross section proton-proton and proton-nucleus at energies above 10^{18} eV using the gluon saturation hypothesis [2]. The gluon saturation physics can be implemented in some hadronic interaction model and through studied of extensive air shower we will show the effect of gluon saturation in the interpretation of cosmic ray by composition.

Keywords: extensive air shower, hadronic interaction, gluon saturation

1 Introduction

Ultra high energy cosmic rays ($E > 10^{17}$) studies are based on detection of extensive air showers and from that we can obtain three informations about the primary particle: arrive's direction, mass and energy. However, the interpretation of the mass composition relies on the interaction hadronic model, such as, the requirement of extensive air shower simulation to interpret the cosmic ray mass through of the elongation rate. In highest energies, cosmic rays have three orders of magnitude higher energy than the reach of the largest particle accelerator, LHC (Large Hadron Colidder). Consequently, the mass interpretation of ultra high energy cosmic rays requires extrapolation of interaction hadronic parameters, due to nonexistence of experimental data at this energies.

Ralf Urich showed in [1] how extensive air shower parameters changes as a function of several hadronic interaction parameters: cross section, multiplicity, elasticity and charge ratio. He modified the parameters scale by a factor that depends of the energy $f(E, f_{19})$, given by

$$f(E, f_{19}) = 1 + (f_{19} - 1)F(E) \tag{1}$$

with

$$F(E) = \begin{cases} 0 & E \leq 1\ PeV \\ \frac{log_{10}(E/1\ PeV)}{log_{10}(10\ EeV/1\ PeV)} & E > 1\ PeV \end{cases}$$

In this paper, we will present during the conference the effect of new cross section models based on gluon saturation. The motivation of this work is given by reference [2]. We will present the calculation of the proton-nucleus cross-section, compare it to the standard Glauber model and illustrate its effects on the mass composition interpretation.

Acknowledgment: This work has been supported by CAPES, PROEX, CNPq and FAPESP.

References

[1] RALF ULRICH and et. al, Physical Review D 83 (2011) 054026 doi: 10.1103/PhysRevD.83.054026.
[2] L. PORTUGAL and T. KODAMA, Nuclear Physics A 837 (2010) 1-14 DOI: 10.1016/j.nuclphysa.2010.02.007.