Preface

Cosmic Rays are relativistic particles coming somewhere from outer space and hitting on the top of the earth's atmosphere. The energy spectrum of these particles spreads over a wide range of energies, from a few hundred MeV to more than 10^{20} *eV, the flux of which can be described well by a single power law with negative spectral index. However, the spectral index of the spectrum changes at least two energies; one around 3 PeV where the magnitude of the spectral index changes from about 2.7 to 3.1 i.e. the spectrum becomes steeper above this energy which is known as the knee of the cosmic ray energy spectrum and again the spectral index takes it original value of 2.7 above about 5 EeV which is known as the ankle of the energy spectrum.*

The origin of the knee is not convincingly known yet. Several models have been proposed in the literature so far but none of them are free from problems. The existence of the knee in the spectrum is definitely an important imprint of the true model of origin of cosmic rays and hence a proper explanation of the knee is expected to throw light on the problem of cosmic ray origin. The present thesis presents theoretical and Monte Carlo simulation based study of the knee of the cosmic ray energy spectrum. Particularly we critically examine the existence of the knee in the cosmic ray energy spectrum through detailed Monte Carlo simulation studies of cosmic ray extensive air showers. We then propose a new model of the knee, based on the mass distribution of progenitor of cosmic ray sources, which is devoid of the lecunas of the existing models.

The organization of the thesis is the following:

In ***Chapter 1*** *of this present work a general introduction to the cosmic rays and some of its important features are summarized.*

Large number of experiments are going on in order to study cosmic radiations in different energy ranges with ground based installations, balloons and satellites through the detection of both primary & secondary cosmic ray particles. Several theoretical models have been proposed in order to explain the origin of the primary cosmic rays, their acceleration and origin of the knee in primary energy spectrum. In ***Chapter 2*** *the experimental results and theoretical models are discussed briefly. The present status of the knee problem is also summarised.*

In order to find out informations about primary particles from secondary particle informations, it is important to reconstruct the air shower, through monte-carlo simulation which includes various hadronic interaction models. For that, verification of these models at different energies and atmospheric depth is required. In ***Chapter 3*** *of this work , these air shower reconstruction methods and monte-carlo simulation programs are briefly described. Also the consistency of some of these simulation programs are checked by comparing the simulated results with other experiments.*

In ***Chapter 4****, using these above mentioned simulation methods, verification of low energy hadronic interaction models in use are done by cross checking the simulation results with experimental data. The material presented in this chapter has been published in Astroparticle Physics (Elsevier) (Arunava Bhadra, Biplab Bijay, Sanjay K. Ghosh, Partha S. Joarder, Sibaji Raha, "Influence of microscopic particle interaction models on the flux of atmospheric antiprotons", Astroparticle Physics,* ***35****, 277 (2012) (doi 10.1016/j.astropartphys.2011.09.002)) which is attached at the end of the thesis.*

In ***Chapter 5*** *, a critical examination of various relevant features of primary cosmic rays around the knee energy using Monte Carlo simulation (CORSIKA) and search for any new feature is done. The material presented in this chapter has been communicated (Biplab Bijay, Prabir Banik, Arunava Bhadra, "The knee in the cosmic ray energy spectrum from the simutaneous EAS charged particles and muon density spectra", eprint arXiv:1511.05739) which is attached at the end of the thesis.*

In ***Chapter 6*** *, a new model of cosmic ray knee is proposed based on mass distribution of progenitor of cosmic ray sources. The material presented in this chapter has been published in Research in Astronomy & Astrophysics (Biplab Bijay, Arunava Bhadra, "Progenitor model of cosmic ray knee", Research Astron. Astrophys* ***16****, 6 (2015) (doi: 10.1088/16744527/16/1/006)) which is attached at the end of the thesis.*

In ***Chapter 7****, the summary of this present work along with a brief discussion is presented.*