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Review

Baryons and baryon resonances in nuclear matter

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ABSTRACT

Theoretical approaches to the production of hyperons and baryon resonances in elementary hadronic reactions and heavy ion collisions are reviewed. The focus is on the production and interactions of baryons in the lowest SU(3) flavor octet and states from the next higher SU(3) flavor decuplet. Approaches using the SU(3) formalism for interactions of mesons and baryons and effective field theory for hyperons are discussed. An overview of application to free space and in-medium baryon–baryon interactions is given and the relation to a density functional theory is indicated. The intimate connection between baryon resonances and strangeness production is shown first for reactions on the nucleon. Pion-induced hypernuclear reactions are shown to proceed essentially through the excitation of intermediate nucleon resonances. Transport theory in conjunction with a statistical fragmentation model is an appropriate description of hypernuclear production in antiproton and heavy ion induced fragmentation reactions. The excitation of subnuclear degrees of freedom in peripheral heavy ion collisions at relativistic energies is reviewed. The status of in-medium resonance physics is discussed.

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1. Introduction

In the early days of nuclear and elementary particle physics the plethora of particles observed in high energy experiments casted doubts on their elementary particle nature. Obviously, a new approach was necessary allowing to bring order into the data. The group-theoretical approach introduced independently by Murray Gell-Mann and Yuval Ne'eman in the beginning of the sixties of the last century, leading finally to the quark model, was the long awaited for breakthrough toward a new understanding of hadrons in terms of a few elementary degrees of freedom given by quarks and gluon gauge fields as the force carrier of strong interactions. One of the central predictions of early QCD was the parton structure of hadrons. Once that conjecture was confirmed by experiment in the early 1970's [1], Quantum Chromo Dynamics (QCD) has evolved into the nowadays accepted standard model of strong interaction physics, describing hadrons by quarks and gluons with color and flavor quantum numbers. Renormalization group techniques and regularization methods, asymptotic freedom on the one side and quark confinement on the other side are defining parts of strong interaction physics. The Higgs-mechanism is responsible for the non-vanishing masses of the current quarks. Gluon self-interactions and effects from the spontaneously broken chiral symmetry are important ingredients of constituent quark and hadron masses. The highly non-linear nature of QCD inhibits analytical or perturbative solutions for most of the accessible energy region, except for the highest energies as e.g. reachable at the Large Hadron Collider (LHC) at CERN. Since long, QCD theory has become part of the solid foundations of