

Charged pion ratio in heavy ion collisions as a probe of the nuclear symmetry energy at high density

Abstract: Knowledge on the density dependence of nuclear symmetry energy, which is a measure of the change in the binding energy of a nucleus when a proton is converted to a neutron, is important for understanding the structure of rare isotopes of large neutron or proton excess and many issues in nuclear astrophysics. Collisions between neutron-rich nuclei provide the possibility to study the nuclear symmetry energy at various densities. In particular, theoretical studies have shown that the ratio of negatively to positively charged pions produced in a heavy ion collision is sensitive to the nuclear symmetry energy at high density. However, very different conclusions have been obtained from the analysis of the experimental data measured by the FOPI collaboration at GSI. Depending on the transport model used in these analyses, some find that the measured charged pion ratios can be described by a stiff symmetry energy while others show that they are consistent with a super soft symmetry energy that vanishes at about three times normal nuclear matter density. In this talk, I will review these theoretical results and also discuss effects that are neglected in these studies, such as the pion optical potential and the medium modification of the pion production threshold. To gauge the accuracy of the transport models that have been used for heavy ion reaction studies, I will further discuss the results from two comprehensive studies in which a multitude of predictions from many transport models are compared.