Title

Moment of inertia tensors of relativistic and non-relativistic nucleons using a parton model

Authors

Milagros L. Wilson[1] and Jorge A. Munoz[1,2]

[1]Department of Physics and [2]Computational Science Program, The University of Texas at El Paso, El Paso, TX

Abstract

Neutron star formation is governed by the β-decay nuclear reaction that transforms protons and electrons to neutrons and neutrinos. This study describes a classical model that estimates the Gibbs free energy associated with this phenomenon from the equilibrium constant of the nuclear reaction (K). Previous work based on this idea had assumed a three quark model for the proton and neutron and calculated K by finding the moment of inertia of a rigid asymmetric top for each nucleon. Differences in rotational energy between the nucleons were estimated using this method and an overall Gibbs free energy was found.

We build on that method by creating a Jupyter Notebook-based model with the assumption that the proton and neutron charge distributions will be equal to their distributions of mass, partly attributed to Feynman's Parton Model. We use the charge distributions to generate three-dimensional data frames of random points for each nucleon. Finally, we calculate the moments of inertia and find K. From K, we obtain the Gibbs free energy of the nuclear reaction. This was done for both non-relativistic and relativistic charge distributions to determine any difference in the energy between the two. Graphical demonstrations show a clear shift from the pattern observed for the non-relativistic nucleons (roughly spherical) vs relativistic (diamond-shaped top). Differences between the proton and neutron themselves were also found.