Waiting for The Potential

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ABSTRACT

Four forces are used for understanding the amazing universe. One force among them about which we are curious is the nuclear force of nature. Although it is the strongest force among all, we are unable to experience this force due to its short-range effectiveness. The present article discusses the possible reason behind the fact that there is no definite expression for such a strong interaction.
KEY WORDS: *Forces of nature, nuclear potential, Igo ambiguity, Unification of theories.*

INTRODUCTION

When we see nature and the natural phenomena taking place, we ask many questions to ourselves. Why does Earth revolve round the Sun? How do the planets stay in orbits around the Sun? How does sunray travel to reach us? How does the Sun produce so much heat energy? Why do stars twinkle in the sky? Why the plants are green, but our blood is red? Why do nuclei form atoms and the atoms come together to give us matter? Why do pieces of magnet repel or attract each other? And many more. In toto, we are eager to know *why the phenomena are the way they are*. In particular, while finding the answers to the questions related to repulsion and attraction, we come across an important physical quantity called *force*. Interestingly, we have been working for centuries to describe the various forces that dictate interactions on the largest and smallest scales, from huge planets to invisible particles. The nature of interactions is almost the same everywhere, but their strength and properties differ. Based on the various factors the interactions are basically categorized into four types. Thus, there are four fundamental forces in nature. The four fundamental forces are:

(i) Gravitational force,
(ii) Electromagnetic force,
(iii) Strong nuclear force, and
(iv) Weak force.

At present, we deal with only these four fundamental forces to explain so many phenomena of nature, but we are unable to explain all the natural phenomena. Although these forces are responsible for shaping the universe we inhabit, they have limitations to analyse certain strange behaviors of nature. The gravitational force and the electromagnetic force are familiar forces, because, such interactions are experienced by we all in our daily life. But, the other two forces are still not familiar to common people. Moreover, the strong nuclear force is still in mystery. As the nuclear force acts within very small dimension of nucleus, we deal with nuclear potential that represents the nuclear force. However, there is no definite formula for the nuclear potential unlike gravitational potential and electromagnetic potential.

DISCUSSION

Although nuclear forces affect our daily lives, we are unable to feel them. It is because they work on distances smaller than atoms. Nuclear force that holds together the building blocks of atoms is the strongest interaction in the nature, but it is short range. This force is essential to hold together the protons and neutrons in order to build nuclei. The force also acts within neutrons and protons which are built up when the strong force holds together the tiny quarks.

The making of nucleus with protons and neutrons as ingredients cannot be explained by electromagnetism and gravity. If we consider only the electromagnetic and gravitational forces, then the nucleus should fly off in different directions due to pre-dominant repulsion. The interaction taking place in the strong nuclear force is about 100 times stronger than electromagnetic interaction. If we compare with gravity, then the strong force is about 10^{38} times stronger than the gravitational force. But the influence of nuclear force quickly dies for anything larger than the nucleus of a medium-sized atom. The nuclear force will be disappearing and other forces will be dominating outside the atoms. The interaction is simply amazing and uncommon. The charged protons having similar polarity even attract each other with nuclear forces inside a nucleus in order to build up the nucleus. Even the neutral neutrons attract each other with nuclear forces inside a nucleus. Thus, it is the nuclear force for which the existence of elements is possible and the formation of matter is achievable. Thus, it is the strongest nuclear force for which the present universe is due.

We are in a position to describe the cause behind the presence of nuclear force, but equally unable to find a definite expression for such a strong interaction. It is now a challenge for the researchers to know the true form of nuclear potential existing between all pairs of nucleons. If only one knew the strong-interaction between the nucleons, then perhaps solution of the Schrodinger equation would provide a basic understanding of the properties of nuclei. The problem of deriving such a potential has been attacked by the foremost theoretical and experimental nuclear physicists. The job of defining such potential has become a phenomenological one, involving the acquisition of large amounts of data from various scattering experiments in different laboratories.

In order to define nuclear potential the optical model potential (OMP) is one of few established methods for analyzing experimental data obtained from nuclear interactions. The elastic scattering angular distributions are usually analyzed in the framework of OMP, which can be extended further to analyze many complicated nuclear phenomena. Parameters of the potential can be extracted by effective comparison of theoretical calculations with experimental values. Despite large number of system-studies and huge data, the nuclear potential is not uniquely described till date. A little agreement is found among different analyses [**1**]. A number of OMPs fit theoretical calculations with experimental data and explain the results. Numerous different families of OMP parameters successfully describe the same experimental data, but the families have no satisfactory correlation among them. This leads to *Igo ambiguity* [**2**] as pointed out by George Igo. To settle down such ambiguity we may cite alpha-particle elastic scattering experiments in low and medium energy range. The experiments are very sensitive to the surface of the nuclear potential, but yield no information about the central part of the nuclear potential [**1**].

The root cause of the problem lies behind the dynamics of heavy-ion elastic scattering. We expect the features of the nuclear potential by the analysis of elastic studies. But strong absorption due the nuclear potential hides most of the features we wish to explore from easy investigation. There exists repulsion for projectile particles near the Coulomb barrier which is located at the surface of nucleus. Once the projectile overcomes the Coulomb repulsion at the surface boundary, it can reach the highly attractive region inside the nucleus. Particles which enter the stronger parts of the nuclear potential are absorbed and never emerge. Therefore, we are unable to gather actual information about the nuclear potential. On the other hand, we obtain mostly those particles in elastic scattering experiments which are affected mainly by the strong Coulomb repulsion between a heavy ion and a nucleus. Only a very small fraction of the flux of elastically scattered particles carries information on the details of the nuclear potential. So this information bears on the potential only in a localized radial region. That’s why any derived potential which approximates the interaction in this region will give acceptable fits to elastic scattering data. As a result of which the nuclear potential is not uniquely described till date in spite of huge experimental data.

The problem of ambiguity may be solved by choosing correct parameters of the suggested nuclear potentials. The parameters can be accurately determined by the elastic scattering, if the OMP is considered within sensitive region. Thus the sensitive radial regions of the potential have to be located which region will be suitable for the analysis of scattering data. The sensitive region of OMP can be investigated by using the *notch-perturbation method* [**1**,**3**], a reliable and simple technique possessing evident advantages. This method was successfully applied for an elastic collision system $^{14}N+^{56}Fe$ [**4**] to investigate the radial sensitivity in which ^{14}N is a tightly-bound projectile upon the target ^{56}Fe.

CONCLUSION

The number of phenomena occurring in our nature cannot be counted. We and even our devices are unable to detect them all. We have observed or sensed a few. Various theories help us analyse and understand natural phenomena. As of today, we deal with a huge number of laws to understand a few natural phenomena. Therefore, the number may not be imaginable in order to understand or explain all the phenomena. This may create ambiguity in future. Therefore, our endeavor must be in a line to understand the universe with unified laws.

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