Cumulative Interactions (to explain the existence of the particles emitted with the energy near kinematics limit)

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Abstract
The energy of the cosmic rays, recently measured with thousands of coincident detectors in different laboratories of the world, can reach unusual values like: tenth or hundreds of TeV. Since an human accelerator (or space, galactic one) was not imagined up to now to verify different hypothesis, we try to explain this accumulation of this enormous amount of energy in the one small particle by a possible cumulative interaction. This kind of interactions are also observed in the heavy ions nuclear reaction when light particles, protons, alphas, etc., are emitted with the energies near kinematics limit. The cumulative interaction seems to have an probabilistic character. In this contribution we try to understand the relation between the gravitational interaction and the cumulative interaction.
Keywords: cumulative interactions, gravitation, electromagnetic interaction, weak interaction, nuclear interaction.

1 Introduction: Towards Grand Unification

The dream of the physicists are to find a general theory able to give an unified view of all the actually known interactions: gravitation, weak, electromagnetic and nuclear under the name of grand unification. Already important step have been made by Salam and Glashow in their electreoweak theory. A big hope come from the string theory for gravitation. Some physicists hope that by taking unto account the electromagnetic interaction in the string theory calculation for the gravitational interaction will be able to explain for example : the difference in the measured values of G (gravitation) constant, measurements realised at different latitude of the Earth.

2 The Matter and the Four Interactions

a) Gravitation

The gravitational force is universal, and every particle feels the force of gravity, according to its mass or energy. Gravity is the weakest of the four forces by a long way; it is so weak that we would not notice it at all were it not for two special properties that it has: it can act over large distances, and it is always attractive. This means that the very weak gravitational forces between the individual particles in two large bodies, such as the earth and the sun, can all add up to produce a significant force.

In the quantum mechanical calculations of the gravitational field, the force between two matter particles is pictured as being carried by a particles of spin 2 called **the graviton**. This has no mass of the exchange of gravitons between the particles that make up these two bodies. Although the exchanged particles are virtual , they certainly do produce a measurable effect – they make the earth orbit the sun. Real gravitons make up what classical physicists would call gravitational waves, which are very weak – and so difficult to detect that they have never yet been observed.

b) Electromagnetic interaction

The electromagnetic force, is the interaction between electrically charged particles like electrons and quarks, but not with uncharged particles such as gravitons or neutrons. This force is much stronger than the gravitational force: the electromagnetic force between two electrons is about 10^{40} times bigger than the gravitational force.

The force between two positive charge is repulsive, as is the force between two negative charges , but the force is attractive between a positive and a negative charge. A large body, such as the earth or the sun, contains nearly equal numbers of positive and negative charges. Thus the attractive and repulsive forces between the individual particles nearly cancel each other out, and there is very little net electromagnetic force. However, on the small scales of atoms and molecules, electromagnetic forces dominate.

The electromagnetic attraction between negatively charged electrons and positively charged protons in the nucleus causes the electrons to orbit the nucleus of the atom, just as gravitational attraction causes the earth to orbit the sun. The electromagnetic attraction is pictured as being caused by the exchange of large number of virtual massless particles of spin 1, called **photons**. The photons that are exchanged are virtual particles. However , when an electron changes from one allowed orbit to another one nearer the nucleus, energy is released and a real photon is emitted – which can be observed as visible light by the human eye , if it has the right wavelength , or by a photon detector such as photographic film. Equally, if a real photon collides with an atom, it may move an electron from an orbit nearer the nucleus to one farther away. This uses up the energy of the photon, so it is absorbed.

c) Weak interaction

The weak nuclear forces is responsible for radioactivity and which acts on all matter particles of spin ½ , but not on particles of spin 0,1 or 2 such as photons and gravitons. The weak nuclear force was not well understood until 1967, when Abdous Salam and Steven Weinberg proposed theory that unified this interaction with the electromagnetic force, just as Maxwell had unified electricity and magnetism about a hundred years earlier. They suggested that in addition to the photon, there were three other spin 1 particles, known collectively as massive vector bosons, that carried the weak force. These were called W^+, W^-, and Z° and each had a mass of around 100 GeV. The Weinberg – Salam theory exhibits a property known as spontaneous symmetry breaking. At high energies all these particles behave similarly.

In the Weinberg – Salam theory, at energies much greater than 100 GeV, the three new particles and the photon would all behave in a similar manner. But at the lower particle energies that occur in most normal situations, this symmetry between the particles would be broken. W^+, W^- and Z° would acquire large masses making the forces they carry have a very short range. The three massive partners of the photon, with the correct predicted masses and other properties was discovered in 1983 at CERN by Carlo Rubia and Simon van der Meer.

d) Nuclear interaction

The nuclear forces, which holds the quarks together in the proton and neutrons together in the nucleus of an atom. It is believed that this force is carried by another spin 1 particle, called the gluon , which interacts only with the quarks.

The strong nuclear force has a curious property called confinement : it always binds particles together into combinations that have no color. One cannot have a single quark on its own because it would have a color (red, green or blue). Instead, a red quark has to be joined to a green and a blue quark by a "string" of gluons (red + green + blue = white). Such a triplet constitutes a proton or a neutron. Another possibility is a pair consisting of a quark and an antiquark (red + antired, or green + antigreen or blue + antiblue = white). Such combinations make up the particles known as mesons, which are unstable because the quark and antiquark can annihilate each other, producing electrons and other particles. Similarly , confinement prevent one having a single gluon on its own, because gluons also have color. Instead , one has to have a collection of gluons whose colours add up to white. Such a collection forms an unstable particle called a glueball.

The fact that confinement prevents one from observing an isolated quark or gluon might seem to make the whole notion of quark and gluons as particles somewhat metaphysical. However, there is another property of the strong nuclear force, called asymptotic freedom, that make the concept of quarks and gluons well – defined. At normal energies , the strong nuclear force is indeed strong, and it binds the quarks tightly together. However, experiments with large particle accelerators indicate that at high energies the strong force becomes much weaker , and the quarks and gluons behave almost like free particles.

Four known interactions

Symbol	Name	Date	Intensity	Domain
G	**gravitational**	**(1680)**	**5 10^{-39}**	(stability of the galactic matter)
W	**weak**	**(1933)**	**6 10^{-13}**	(particle transformation, beta decay)
EM	**electromagnetic**	**(1868)**	**1/137**	(stability of the atom, crystals, gamma decay)
S	**strong**	**(1934)**	**15**	(stability of the nuclear matter; alpha decay)

(The cumulative interaction was not proposed up to now. From the experimental data on heavy ion reaction we inferred the existence of this kind of interaction responsible for appearance of the complex particles

C **cumulative interaction:** **10^{-25}** (creation of new nuclei)

Experimental facts suggests a relative intensity of the order 10^{-25} .)

3 Experimental Facts From Heavy Ions Reaction at Medium and High Energies

In the beginning of the twenty century the only projectile in nuclear reaction was the alpha particle emitted in a process of alpha decay. In last decades of all the natural nuclei was accelerate and relative high energy was available to induce nuclear reactions with heavy ions. The complexity encountered in experiments of high energy physics become customary in nuclear reaction where particles, gamma or electrons are measured in coincidence. Nevertheless the simplified model are to be used to extract valuables parameters of the nuclear matter.

The extremes values of the spins or energies have been measured from decay of excited "compound" nuclei . The compound nucleus notion introduced by Niels Bohr in 1934 is far from the reality suppose to describe.

When the nucleus is forced to rotate up to the spin = 100h the nuclear matter seems to have a solid matter characteristics.

3.1 Old ideas DNS (double nuclear system) criticism

The approaching two peace of nuclear matter (two nuclei, roughly two spheres) reach a distance d_f (greater than $R_1 + R_2$ the radius of the two nuclei) where and when the two peace of nuclear matter become one. It is formed a kind of nuclear magma, but with nuclear properties well defined [1] for example the binding energy, excitation energy, angular momentum etc.

3.2 Volkov explanation DNS (double nuclear system) evolution

Volkov [2] suggested a simple model for the fusion of two nuclei: a gentle changing of the nucleons between the two touching nuclei, where only the surface of the nuclear matter was melting and followed by transfer of the nucleons in an unpaired mode to the partner. With this model we interpreted rather well the cross sections of hundreds products in different heavy ion reactions [3], [4], [5] . An extrapolated studies to include other degree of freedom like isospin are presented in the same kind of DNS model [6] Some details of the evolution of the fused system are presented in [7].

The mean nuclear field in each nuclei change when add nucleons, and a new mean field govern the movements of the nucleons. This kind of radical transformation can't be realised in steps. A rearrangement of the nuclear matter implied that the old edifice is destroyed and a new one are build from the foundation. Somehow the binded nucleons went in an unbounded state , a kind of nuclear magma which trough an special interaction (which will bind the particles, neutrons and protons) will reconstruct the nucleus. Experimental facts in nuclear reactions or decay suggest that the properties of the nuclear matter can be a gas, or a liquid or a solid.

3.3 Reconstruction of the new nuclei from fused matter trough the cumulative (three body) interaction

The nuclear fused matter is changing the structure toward a minimum of potential energy, trough a kind of "energy crystallisation". In a nuclear magma resulting from nuclear fusion [1] the cumulative interaction glues the nuclear parts redistributing the energy between that parts. One of them (parts: nucleons, small nuclei, gamma) are escaping tacking away a part of fused nucleus energy More energy are involved in fusion faster the parts are emitted **[9]**. Finally, the cumulative interactions does glues all the parts in a new relatively cold nucleus which find the ground state by usual decays.

The cumulative interactions can happens sequentially or simultaneously.

The cumulative interaction (in nuclear matter) is a three particles (nucleons or small nuclei - associations of few nucleons) colliding in the nucleus. From three body (for example one , two and three) collision in the entrance channel , we obtain two body (for example four and five) coming out in the exit channel. The result of cumulative interaction is a new entity (two binded particles) and the third which cumulate all the energy. For example one and two come out in a bounded new peace of nuclear mater and the third particle take all the energy (kinetic and binding energy resulted from cumulative interaction). The processes can be sequential. If kinetic energy are distributed between the both partners coming out from the interaction, than we have a partial cumulative interaction. The processes of cumulative interaction is very fast (less than 10^{-24}s).

3.4 PNKL as evidence of cumulative interaction

The PNKL (particles near kinematics limit) are expulsed in the heavy ion reaction. They live the nucleus in a ground state, without excitation energy. The simplest model Maxwellian type do not support their appearance. Neither direct kind of model are not capable to explain these particles.

In the hypothesis of cumulative interaction, it is possible to cumulate at the end of chain of this kind of interaction, when three particles (A , B and C) collides in the entrance channel and only two appear in the exit channel (A binded B - formed AB and C). The energy of the C particle increase in each step of the chain. The estimated probability agree with the values extracted from the experimental dates.

4 Conclusions

We suggest the existence of the new interaction , cumulative interaction acting in the nuclear mater, like nuclear and weak interaction. This interaction is not usual two body – two body classical interaction. Based on vortex of five particles, three in incoming and two in outgoing channel this interaction can explain the reconstruction of the nucleus from the hot gas in the energetically heavy ion reactions, or simply explain the formation of the alpha particles in the alpha decay phenomena.

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