Recycling of Atomic Nuclei on the Scale of the Universe – A Proposed Mechanism

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Summary

A mechanism is proposed by which the cosmic abundance of elements is achieved in a model of the Universe that is infinite in time and space. The mechanism is a dynamic equilibrium between the formation of metallic nuclei in stars and their destruction under the same extreme conditions of temperature and pressure. Metallic nuclei are reduced to fundamental particles by collision with each other at high velocities, and the resulting particles are ejected in explosions as protons, electrons and neutrons which reform into hydrogen atoms and hence hydrogen gas to begin the cycle of agglomeration and star formation all over again. The result is that the Universe as a whole is regenerated part by part, the total composition remains the same, there is no possibility of entropic degradation and the total energy transported between bodies as electromagnetic radiation remains constant.

A. Introduction

Atomic nuclei are generally considered to be indestructible nuggets of matter, but it is proposed in this paper that they may disintegrate more easily than commonly imagined, not by chemical or even electromagnetic means, but by mechanical force. Nuclei are seldom subjected to mechanical force under the circumstances which we consider to be normal, because they are always surrounded by shells of electrons, which cushion any blow. Chemical reactions concern the rearrangement of the electron shells, but the nuclei remain unaffected; transmutation of elements is still quite difficult! Electromagnetic forces also involve the displacement of electron shells, but this does not lead to transmutation, even if the shells are stripped them away completely.

Nuclei can come under mechanical attack only when they have lost their protective electron shells and collide with similarly unprotected nuclei. This requires considerable momentum because of the mutual repulsion of their positive charges, but if collision is sufficient to displace even one of the intranuclear electrons which bind protons together, then according to previous analysis the orbits of all the others unravel and the structure unzips because of the imbalance of charges. The outcome is complete disintegration into protons as the electrons flee the scene first, and the protons follow because of the mutual repulsion of their positive charge, but more slowly because of their much greater mass. Neutron bombardment cannot have the same effect, partly because the neutron's electron in close orbit is repelled by the intranuclear electrons of the nucleus, and so it does not get close enough, and partly because as a single particle it does not have sufficient momentum to break through. Thus the only likely contender is the head-on collision of heavy nuclei, stripped of their protective shells, at high velocities, probably close to those normally described as relativistic. The reasoning for these conclusions arises from consideration of the alternative theories of the origin of the Universe.

B. The cosmic setting

There are two incompatible theories of the origin of the Universe. The theory most in favour at the moment is that it all began about 14bn years ago with the mother of all expansions from a single point, at which time and space were created, and which still leaves everything racing away from everything else today. Evidence of this is considered to be the redshift of light from stars and the relative abundances of elements in the Universe as a whole. Sceptics might say that there could be other explanations of the reduction of electromagnetic frequencies in space, and in the same way there may be other reasons for the cosmic abundances of elements observed by astronomers. There is a certain circularity in the argument for the expansion model; deductions from redshift and the patterns of spectral analysis of light may be mutually consistent, but that does not mean that they are linked by the same event.

The other theory is that the Universe is infinite in time and space. The parts which we can see keep on changing, but the Universe remains constant overall; indeed this is implicit in the concept of infinite time and space. This prompts the rejoinder that the entire Universe should be composed of heavy metallic elements by now, because heavy elements are built up apparently irreversibly from those with lower atomic numbers, and so in the course of infinite time all elements would have reached the highest atomic number. This has definitely not occurred, because the bodies of which the Universe is composed are observed to consist almost entirely of hydrogen. Everything else is trace elements.

However, it might justifiably be pointed out that by the same sort of argument all matter in the Universe ought to be in one large lump, because of gravitational attraction, which it manifestly is not. The reason is that the agglomeration of matter certainly occurs, and all bodies in the Universe are in ceaseless motion, which leads to this process, but when bodies reach a large enough size, nuclear reaction sets in under the conditions of extreme pressure and temperature, and they eventually collapse and then explode, thus scattering the parts all over the Universe again, though of course to different places, in effect redistribution and regeneration. It must be more complicated than that because we have not only stars, which have been described in these very broad brush terms, but also separate collections of stars called galaxies. Nevertheless, the general principle is clear enough.

Similar reasoning may be applied to the cosmic abundance of elements in the Universe, if there exists a mechanism for returning heavy nuclei to their original building blocks, namely protons and electrons, and that is what this paper suggests.

Nuclei of higher atomic number are forged from hydrogen in the heat and pressure of stars. This leads to the combination of protons and electrons into structures which we have seen as protons and neutrons, because the balance of charges between orbital electrons and nucleus suggests the presence of neutral particles of about the same mass as protons. My previous paper proposes that all the large particles are in fact protons, and there are electrons inside the nucleus in close orbit around assemblages of protons i.e.

intranuclear electrons, which cancel out the charges of the additional protons. It is the synchronised orbit of the intranuclear electrons which binds the whole nucleus together. As soon as this is disrupted, the entire nucleus flies apart into electrons and protons again.

I suggest that the same conditions of stellar pressures and temperatures which cause the combination into heavier nuclei are the same as those which favour their disintegration through collision. At the beginning of the process there are only protons and electrons, which are becoming dissociated from their hydrogen structures because of the conditions. Their re-association into heavier nuclei is a process of stochastic collision which depends on the concentrations of each. The heavier the metallic nucleus, the more complex it is, and so the less likely it is to form. Thus the concentration of heavier nuclei formed will decrease with increasing atomic number. However, the proportion of metallic nuclei which is formed remains so small in relation to the starting materials that the rate of formation is scarcely affected by depletion of protons and electrons during the process, other things being equal. By contrast, the process of destruction of metallic nuclei through collision starts from zero, because there can be no such collision until at least two metallic nuclei are present. The rate of destruction thereafter increases rapidly as the proportion of metallic nuclei increases, probably accompanied by rising temperature, which is increasing particle velocity.

The point is reached at which heavy nuclei are destroyed at the same rate at which they are formed, which is a dynamic equilibrium i.e.

rate of production of metallic nuclei = rate of destruction of metallic nuclei
(from fundamental particles) (by collision of metallic nuclei)

This process accounts for the relative abundances of the elements in the Universe as a whole. The extent to which metallic elements form in a star depends on the temperature attained by the star and the time for which it persists, but in the Universe as a whole the relative abundances remains unchanged for ever.

If this analysis is valid, the cycle of synthesis of metallic elements can be drawn as in the Figure.

Just as the process of synthesis of metallic nuclei requires the stochastic collision of protons and electrons in specific numbers and orientations, so the process of their destruction requires the head-on collision of heavy metal nuclei at high enough velocities to dislodge one or more intranuclear electrons from both nuclei. As soon as this happens, the orbits of all intranuclear electrons are disrupted, their cohesive effect is lost and the repulsive charge of the protons forces them apart.

When the star eventually explodes or becomes involved in an explosion, all its matter is thrown into space in all directions, although there may be directional phenomena in some cases. Particles of matter and the heavier metallic elements will eventually find other

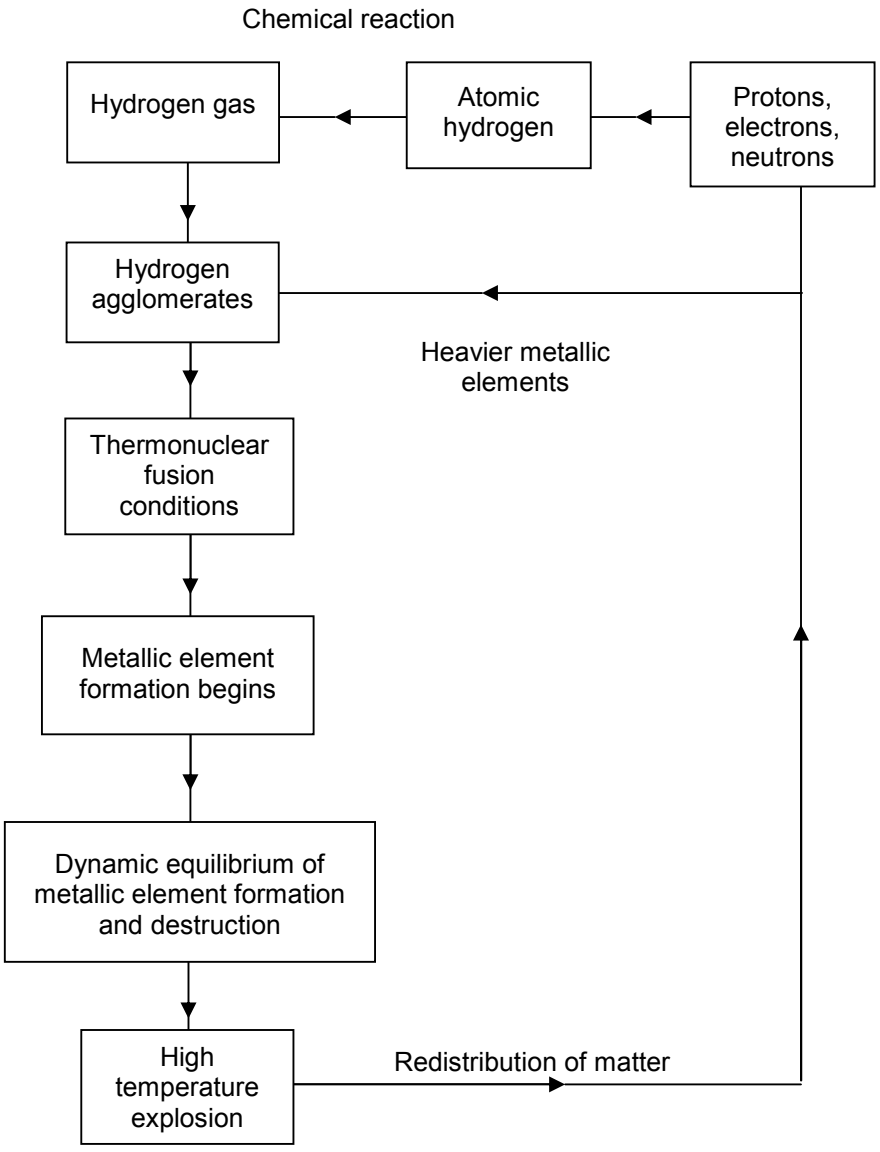

Figure. The Proposed Cycle of Materials in the Universe

bodies with which to amalgamate. Protons and electrons may travel further as individual particles, because they never meet in radial ejections. However, if a third body causes them to deflect and collide, they may associate to form hydrogen atoms.

It is also likely that neutrons could be ejected, because they are extranuclear particles; they are generated when an ejected proton takes an electron with it in close enough orbit to form a unit. Neutrons may survive an indefinite time if they are undisturbed by other particles, but eventually the electron will break out of close orbit and adopt the much larger orbit of the extranuclear electron to form a hydrogen atom.

Hydrogen atoms may themselves remain stable for long periods until the presence of a third body deflects them into collision with enough force to overcome the activation energy of combination to form hydrogen gas.

There is also the possibility that helium nuclei may be ejected as integral units in their own right i.e. as alpha-particles, because these are extremely stable nuclei, not as stable as the subatomic particles electrons and protons, but stable enough to form projectiles. This would redistribute helium throughout the Universe.

C. Conclusions

Such a process of redistribution and regeneration at work in the Universe as a whole was envisaged in the first in this series of papers called *The Timeless Universe: A Model of Stochastic Regeneration and Redistribution*. This Universe is infinite in time and space, and so it must remain constant as a whole, because there is no external degree of freedom against which to change. Thus there is no increase in the entropy of the whole; it is a meaningless concept. Nor is there any loss of energy, because there is nowhere for it to go. What is lost on the swings of gravitational attraction is exactly recovered on the roundabouts of nuclear explosion. Since these changes are all accompanied by the emission of electromagnetic radiation, the total amount of radiation in the whole Universe must represent the exchange between bodies of a quantity of energy which is constant in total. It may also follow that the range of frequencies in this radiation across the Universe is constant, if these are also linked fundamentally to specific energy levels.

This is dynamic equilibrium on the grandest possible scale. There can be no processes which are not reversible in time and space, because this would tilt the Universe in a particular direction. This would have happened a very long time ago, if it was going to happen at all; we would have arrived at whatever was the end point, if there was one, and we would have no way of detecting it, since we are inside the system on which we pass judgment.

Thus calculations based on the rate of formation of metallic elements in stars may not give the full picture. Somewhere else in the Universe there must be an equivalent process which reduces heavy nuclei back to their component protons and electrons to begin the process again. The point of equilibrium in the infinite Universe is determined by the

balance of rates at which metallic nuclei are formed and destroyed. It seems probable that extreme conditions of temperature and pressure are needed for both processes, and the only possibilities are the interior of stars. It may be that different stars perform different functions e.g. one type for synthesis and another for destruction, but the most likely model is that all perform some of each, though the balance may vary with a star's size and age.

The observations on which cosmic models are based are a sample of the infinite Universe. It is quite a good sample, a sphere with a radius of 14 billion light years, but it is not the whole system. There are infinitely more things in heaven and Earth which remain to be discovered.

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