The Ultimate Quest : Theory For Everything!

by Mohd Anisur Rahman

THE most familiar concept about the birth of the universe is the Hot Big Bang model. In this model it is accepted that the universe originated from a primordial fireball of infinite density with infinite temperature. This can be conceived from an infinite mass concentrated in a point volume, known as Big Bang singularity, where temperature is infinite. Such a thing exploded and the explosion is termed as the Big Bang.

At the very earliest moments after the Big Bang, the universe would have contained elementary particles and their antiparticles (antiparticles are the mirror image of real particles, eg. positron in the counterpart of electron with same mass but equal amount of positive charge. If they meet each other, both will vanish within a flash, releasing enormous amount of energy). As the universe started expanding and temperature dropping, particles started combining to heavier forms under the influence of the four forces which are known to have separate identity but thought to have been identical at those initial moments; later on revealed themselves as different aspects of a single force.

Strong nuclear force revealed itself when temperature of the expanding matter dropped down to the level of the hottest stars. At this stage, particles would no longer have sufficient energy to escape the attraction of strong nuclear force and started to combine to form the nuclei of the atom. Once the temperature had dropped to a few thousand degrees, electron and nuclei no longer had enough energy to overcome yet another force, electromagnetic force (the electromagnetic attraction between negatively charged electron and positively charged proton causes the electron to orbit the nucleus of the atom) and they would have started combining to form atoms. With cooling still taking place sample of atoms gave birth to heavier ones and thereby molecules — elements — from simple to heavier forms. The result is the body of the universe as we see it.

Two other forms of forces are gravity and weak nuclear force. Gravity is the force that is felt by any particle according to its mass (or energy). The greater the mass the stronger the gravitational force. It is the gravitational pull that causes the earth go to a round the sun. The weak nuclear force is responsible for some kind of radio activity.

All matter that we see in this universe, including people, air, water, microbes, stars, planets etc. are made up of tiny building blocks called atoms. Atoms are in turn made up of some smaller particles — electron, proton and neutron. Proton and neutron are made up of even smaller particles called quarks. These are elementary particles under the class 'fermions'. There is a separate set of particles which transmits the aforesaid forces between matters in the universe. Such force-carrying particles are under the class 'bosons'. Bosons are of four types corresponding to four forces — gluon is the unit of strong nuclear force. Similarly, photon is for electromagnetic force, graviton for gravity and intermediate vector boson for weak nuclear force. So the entire universe boils down to some elementary particles at the grassroot level. But this view of elementary particles may still, be inadequate until scientists dash into the Big Bang. Unification of forces, truly elementary particles, are going to be unfold only then. It would be possible only then to explain the universe and search for a theory for everything would end there.

This now leads us to think if there is any set of rules complete enough to describe our universe. Many physicists believe that such a set of rules — the Theory for Everything may be within our reach. The theory may contain a set of fairly sample principle, perhaps even just one principle that lies behind everything that has happened, is happening and ever will happen in our universe.

As it can be inferred, the Theory for Everything must give us a model that unifies the forces and particles, discuss boundary conditions of the universe, i.e. the initial conditions at the every earliest moments and also the outer boundary, i.e. if the universe is still expanding, there should be an outer boundary or edge inside which expansion is still taking place; same goes for a contracting universe too. Also it should predict precisely how many types of particles there are. Basically it should give a mathematical model of the behaviour of the universe.

The path to achieve such a theory is definitely not going to be an easy one. We must provide room for enormous complexity although we expect it to be a simple code. Many prominent scientists have set themselves for this ultimate quest. Lots of new concepts are in the offing. For example, superstring theory, one of the most exciting current theories which predicts ten dimensions, may seem crazy at the first look since we often find difficulties in adding the forth dimension, time, to the other three — length, width and breadth. Theorists believe that the other extra dimensions are curled up in subatomic level.

But it is necessary to know that the concepts must combine Einstein's Theory of General Relativity and Quantum Mechanics. The Theory of General Relativity describes the force of gravity and the large scale structure of the universe — planets, stars, galaxies for instance. Quantum mechanics, on the other hand, deals with phenomena on extremely small scales, from atomic to subatomic level and so on. The most useful tool to unify electromagnetic, strong nuclear and weak nuclear forces is quantum mechanics. So, in order to have a unification theory — Grand Unification Theory — a quantum theory of gravity must be discovered. Quantum mechanical, way of looking into gravity, is that gravity is made up of gravitons as light is made up of photons.

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But this 'quantum mechanisation' of gravity has some technical problems. Stephen Hawking, one of the leading physicists working along this line, has had some bizarre results : 'black holes aren't black'; there may not be any boundary conditions, i.e. the universe is as we see it, self contained; then empty space is not really empty — it is teemed with particles and antiparticles which add up to enormous amount of energy.

So there may still be a long way to go before the theory for everything is handy. But we wouldn't be far wrong to expect a positive result at the close of the century.

Now the question arises : if we have a theory for everything, will it be possible to predict every details! Will a young married couple be able to predict their babies crying at any unpleasant hour at night with the help of mathematical formula or how many times will the opposition walk out from the national assembly in a year?

Even if it is possible, how specific can we be? Not every, that's for sure? For the calculations required will be so vast that no imaginable computer can handle it. There is a further problem that uncertainty principle of quantum mechanics restricts our ability to predict things. Uncertainty principle suggests that we can not measure exactly both the velocity and position of a particle at the same time, no matter how successfully we try to observe it. We can learn the precise position of a particle only to give up the velocity.

Taking this limitation into account, physicists have redefined the goal of science that the Theory of Everything will be a set of laws that makes it possible to predict events upto a limit set by the uncertainty principle, which necessarily means that in many cases we will have to satisfy ourselves with statistical probabilities, not specifics.

So, as it appears, the search for the ultimate theory of the universe seems difficult to justify on practical grounds.

But eversince the dawn of civilization, man has been trying to explain the inexplicable, to find order that underlies the nature, to answer the question why we are here and where we come from. His goal is nothing less than a complete description of the universe.

And it is the most persistent and greatest adventure in human history, this search for understanding the universe, how it works and where it came from.

Solar Energy : Still more expensive than conventionally produced electricity. — Photo : INP.

Safety of Nuclear Installations

ALTHOUGH the operating record of nuclear power is good, widespread public concerns about nuclear power and nuclear facilities continue.

The main challenge ahead is to achieve a global record of safe and well-regulated nuclear technologies which are not detrimental to human health and the environment. The Agency plays an important role as a visible instrument of international collaboration to maintain an acceptable safety level worldwide which fosters international consistency and harmonization.

In 1990, the nuclear safety standards advisory group reviewed revised texts of safety guides on earthquakes and associated topics as they relate to siting of nuclear installations, emergency power supplies in the design of such facilities, and staffing and training of operational personnel.

The international nuclear safety advisory group (INSAG) completed deliberations on the question of safety culture and took an active role in providing advice on the project on the safety of WWER-440 model 230 reactors in Eastern Europe.

Safe operation of nuclear installations

Teams of experts from Member States carried out seven pre-operational or operational safety review team missions (OSART) to nuclear power plant sites or plants.

Visits to construction sites revealed a need for basic organizational changes, the application of modern management principles, the introduction of comprehensive quality assurance provisions, and reinforced industrial safety practices.

Growing interest was shown by many countries in the assessment of safety significant events team (ASSET) programme resulting in a significant increase in a activities in this area. As part of a series of five ASSET missions requested on the first generation Soviet designed WWER-440 Model 230 reactors, three missions were conducted to Greifswald (Germany), Bohunice (Czechoslovakia) and Kozloduty (Bulgaria). Later, an ASSET implementation mission to Greifswald was carried out to assist in implementing recommended immediate corrective actions.

An international seminar on the use of unusual events to improve power plant safety addressed the theory and practice of using information, disseminated through reporting systems, to reinforce nuclear power plant safety.

It covered unusual event reporting systems, unusual event reports as a tool to improve safety, event assessment, lessons learned and corrective actions, effect of the feedback process, and objective and effectiveness of reporting systems.

The international nuclear event scale (INES) was finalized and adopted for a one-year trial period. By the end of the year, 25 countries had informed the Agency that they were users of the scale to rate the safety significance of events and had agreed to report to the Agency within 24 hours information on any events of level 2 or above for worldwide dissemination. The rating of the safety significance of nuclear events based on seven levels and three attributes, we described in detail in a users manual.

Although the scale was developed primarily for rapid communication with the public, it has been used increasingly for technical purposes; many incident reporting system (IRS) reports adopted it and ASSETS used it to rate the safety significance of events being studied.

As part of the incident reporting system, the breakdown of the main root cause categories experienced in events reported in 1990 showed 48% were attributed to equipment failure, 26% to personnel error, and 15% to procedural error (with the remaining in other categories).

Emphasis was placed in 1990 on improving the awareness of ageing phenomena and on developing methods for evaluation and management. Reports in this area were produced on safety aspects of ageing, material ageing mechanisms and the detection and mitigation of ageing effects, and the use of probabilistic safety assessment in relation to plant life extension.

Others covered practices for data collection and record keeping and methodilogies for the selection of nuclear power plant components whose ageing should be assessed for management studies, and understanding, monitoring, and mitigation of ageing effects for four safety significant plant components selected for pilot studies. An advisory group was formed to assist countries operating reactors to perform comprehensive safety reviews in the light of available international.

These reviews should form the technical basis for the safety decisions which ultimately should be taken by the countries. Specifically, the reviews aim at identifying design and operational weaknesses that may threaten plant safety and at suggesting safety improvements.

The 324 research reactor facilities operating as of December 1990 provide collective operating experience of more than 10500 reactor years. In 1990, integrated safety assessment of research reactors (INSARR) missions visited facilities in the Islamic Republic of Iran, the USSR (2), and Bulgaria, which was the 100th INSARR mission conducted.

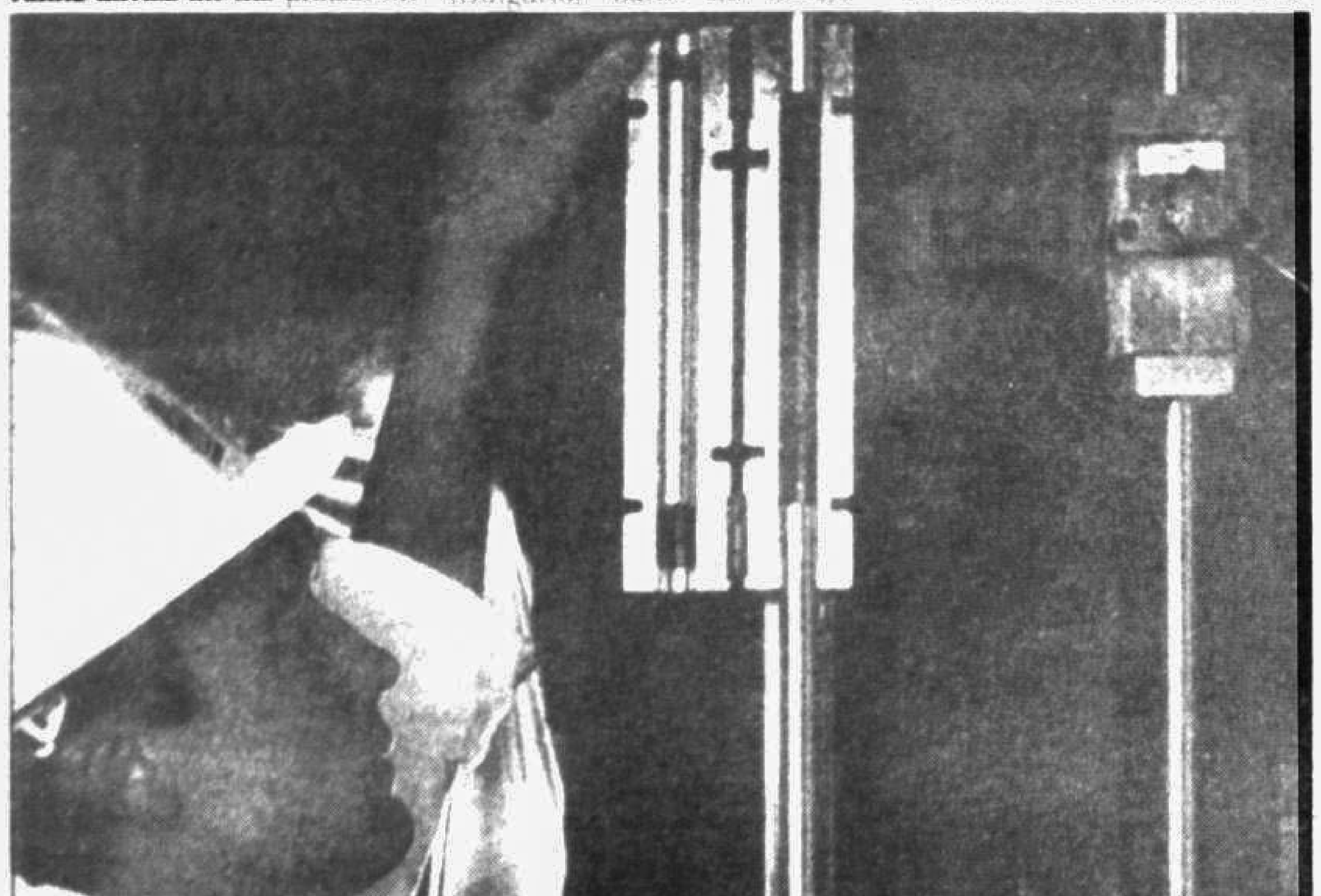
Safety assessment techniques

Work continued in 1990 on standardizing probabilistic safety assessment methodology including specific guidance in the areas of computer codes for probabilistic safety assessment (PSA), treatments of external hazards, common cause failures, human errors, data collection and analysis, and performance of independent peer reviews.

A personal computer based computer code was finalized allowing PSA to be used to predict, for example, the effect on safety of taking components out of service under conditions. The information provided includes impact on core melt probability, likely accident sequences, and the ranking of the importance of equipment relevant for safety.

Work on risk assessment concentrated on the comparative environmental and health impact of different energy systems for electricity production in preparation for the Senior Expert Symposium on Electricity and the Environment held in Helsinki in 1991.

In co-operation with the United Nations Environment Programme (UNEP), the United Nations Industrial Development Organization (UNIDO), and the World Health Organization (WHO), work progressed on a risk management procedures guide for industrial areas involving potentially hazardous installation. — (IAEA)



Maintenance tools are checked before use as part of quality assurance methods in nuclear safety. (Photo: Framatome)

New Duct Robots Improve Indoor Environments

A NEW generation of remote-controlled robots for inspection, cleaning and coating inside mediumsized and large ducts and ventilation shafts has been introduced by Wintclean Air, AB, Swedish specialists in the field of improving indoor environments.

The new robot called Bandy II is equipped with large brushes, a suction unit and a video camera for inspection, runs on caterpillars, and carries a variety of tools for different purposes. The new crawling unit can clean both round and square ducts, sized 150x3000 mm and larger, from dust, fungi, and other substances.

The dirt removed by the brushes is sucked up by the powerful vacuum cleaner, the micro filter of which has a 99.97 per cent efficiency. The robot weighs 10 kg. The choice of brushes is determined by the size and shape of ducts and character of the dust. Wintclean says even heavily contaminated exhaust ducts in the process industry can be cleaned.

Ducts with internal acoustic lining are first cleaned with high-pressure air to remove loose dirt without damaging the surface. The lining is then sprayed with a specially designed coating, which restores it to its original smooth condition and captures remaining fibres, preventing them from being emitted into the air ventilation system.

Saving Ozone Shield Through Sound

By G V Joshi

THERE is renewed pressure on governments of most countries, environmentalists and scientists to tackle ozone depletion in the atmosphere due to man-made chlorofluorocarbons.

It is now well established that when released into the air, choloroflurocarbons rise over a period of years into the stratosphere (atmosphere above 20 km and below 50 km from the earth's surface), where ultraviolet (UV) radiation breaks them down into their components — carbon, chlorine, bromine and flourine.

Chlorine in CFCs destroys ozone, a minor but very important part of the stratosphere, which shields the Earth from much of the sun's harmful UV rays.

Today the family of CFCs includes many hundreds of compounds. But only five of them are considered as most damaging to the ozone layer. They are CFC-11 CFC-12, which are used in refrigerators; CFC-113 used mainly as a cleaning agent, and CFC-114 and CFC-115, which have a variety of uses.

The first three constitute more than 90 per cent of the CFCs. Teflon, the non-reactive polymer used in non-stick frying pans and Halon used in fire extinguishers are also among them.

The main ozone-destroying refrigerant CFC-12 (Freon) could be replaced by another CFC-134a. CFC-12 is very easy to manufacture, but CFC-134a is much more difficult to make commercially. It is also likely to cost three times as much as CFC-12 and may not last as long. It can not be used in present-day refrigerators working on CFC-12 because it is highly corrosive.

The proposed replacement for CFC-11, used to make plastic foam and in central air conditioning systems,. is a compound HCFC-22. This is a CFC already in use in domestic air conditioners and is much more expensive than CFC-11. Its potential applications are limited, however, by its inferior characteristics.

HCFC-22 is not as good a heat insulator as CFC-11 and it is therefore unsuitable as a foaming agent for insulating plastic foams. In addition HCFC-22 is also a CFC and has to be replaced ultimately by 2010 AD., as per the Montreal Protocol.

A Washington-based environmental research institute has issued a report that HCFC-22 is a very harmful chemical and should be banned along with CFCs immediately and not allowed to be used until 2010 AD.

Several groups of scientists and engineers are working on development of new refrigeration technologies that do not depend upon CFCs at all and many even be more efficient than conventional cooling systems. Attempts are also being made to revive old technologies with present-day superior engineering materials.

One of these uses sound energy blasted into a kid of organ pipe to achieve cooling. Developers of sound-driven refrigeration say that such thermoaccoustic devices could chill nitrogen to its liquefaction temperature of — 195.5 degrees celsius or cool the air in a room or an automobile by only a few degrees. One of them was tested aboard the Space Shuttle mission in January this year.

Another of the new refrigeration technologies subjects liquids rather than gases in present-day refrigerators of cycles of compression and expansion to move heat away from the objects being cooled.

Some experts suggest a return to refrigerants like ammonia and sulphur dioxide used during the 1930s before the invention of CFCs. But sulphur dioxide is very toxic and ammonia irritates the lungs. Many easily liquified gases like butane and octane that might serve as refrigerants are undesirable because they pose fire and explosion hazards if released accidently.

Today the family of CFCs includes many hundreds of compounds. But only five of them are considered as most damaging to the ozone layer. They are CFC-11 CFC-12, which are used in refrigerators; CFC-113 used mainly as a cleaning agent, and CFC-114 and CFC-115, which have a variety of uses.

Many other easily liquified gases that might otherwise serve as refrigerants are undesirable because they cause rapid corrosion of metal parts and seals, destroying the compressors, and valves essential in conventional refrigerators.

The invention of CFCs was regarded as a breakthrough because they are non-toxic, non-flammable, noncorrosive and practically indestructible in normal use.

Thermoaccoustic refrigerators have no moving parts, aside from the disphragm of its loud-speaker and can use environment-friendly working gases. Although the design is complex and subtle, the underlying principle is simple.

A loudspeaker at the end of a tube emits an extremely loud note that resonates inside the gasfilled tube to form what is called an accoustic "standing wave' in which individual molecules of gas are in rapid oscillating motion while the wave as a whole does not move at all. Organ pipes and other wind instruments set up similar standing wave resonances.

The gas molecules move back and forth at the same frequency as that of the loudspeaker at the end of the pipe, and as they move they act as microscopic workers in a bucket brigade, carrying heat away from the thinner regions of the standing wave toward its thickest bulge, its antinode.

If a metal plate is placed within this antinode, the plate absorbs heat from the gas molecules and can conduct it away from the refrigerator, leaving cooled gas in its place. The cool gas in turn can draw heat away from refrigerators or air conditioners.

The sound note played by the thermoaccoustic loudspeakers is so loud that it would destroy living tissue exposed to it, but the sound it almost confined in the resonating tube. The noise the user will hear outside is less than the noise of an electric fan.

One thermoaccoustic refrigerator built was tested aboard a space shuttle flight in January 1992, where it reduced the temperature of an object under study by 118 degrees celsius. By modifying the design, the device could be made to move much more heat over a smaller temperature range as required in a household size refrigerator or air-conditioner. Such a unit could chill beer as well as preserve vegetables and meat.

Another group of scientists is working on an entirely different refrigeration system in which liquids rather than gases are compressed under enormous pressure and used to pump heat away from the interior of refrigerators or even rooms, as a matter of fact many liquids like water can be compressed under high pressure and can be even more efficient than compressed gases in moving heat from one place to another as in domestic refrigerators.

In one model, scientists used liquid carbon dioxide, an 'environmentally friendly' gas at one time, at a pressure of 141 kg per square centimeter. However, it must be much more robust to confine this enormous pressure.

The principle of working is the same as in conventional refrigerators. A carbon dioxide refrigerator will be much heavier and bulkier and would be most useful as an industrial plant unit for chilling water which may be used to cool entire buildings.

The ozone depletion problem has finally forced scientists to take a fresh look at the refrigerators and a working solution may come out sooner than expected. However, one thing is clear. A housewife will have to spend more money while buying a new refrigerator and the unit is going to be bigger and bulkier for the same interior capacity.