the moment of the original explosion to come into physical interaction can look so similar, as indicated by the isotropy measurements mentioned above.

The second problem, which in technical terms is known as the "flatness" problem, is directly related to the density of matter in the Universe. It arises from the simple observation that any deviation of the matter density from the "closure" density increases with cosmic time. Thus, if the present density of the Universe is only about 10% of the closure density—as indicated by observations of the content of baryonic matter—at the time when the Universe was only about 100 seconds old (or when the compression factor was ~ 10 billion), the density of matter deviated from the closure density only by one part in one hundred thousand. Most researchers consider this fine-tuning very unnatural and, consequently, believe that the matter density must have always been very close to the "closure" density.

The third problem is concerned with the apparent asymmetry in the matter/anti-matter content of the Universe, that is to say, with the evidence that the Universe is essentially composed of baryons. In the simple standard "hot big-bang" model, there is no reason to think that initially at least the Universe was not highly symmetric, with equal numbers of baryons and anti-baryons in equilibrium with the radiation field: baryons and anti-baryons annihilate into photons and, vice-versa, photons materialize into baryon/anti-baryon pairs. Because of the cooling due to the expansion of the Universe, eventually all baryon/anti-baryon pairs annihilated giving rise to a corresponding number of photons that constitute the universal radiation field now observed at a temperature of 3°K, but somehow a small amount of baryons was left over. That the deviation from a perfect baryon/anti-baryon symmetry should have been small is shown by the fact that presently there are about 100 million photons per baryon (the universal radiation has cooled down to its present temperature of about 3°K because of the expansion of the Universe, but the number of photons has been conserved). If the Universe was baryon symmetric to start with, the above picture of course implies that the baryon number has not been strictly conserved (it should be remembered that a baryon and an anti-baryon add exactly in the opposite way, giving a total baryon number identically equal to zero).

Recent developments in elementary particle physics and fundamental theory, when applied to cosmology, may in fact indicate an elegant way out of these problems. After the successful confirmation of the Glashow, Salam and Weinberg theory on the unification of electromagnetic and weak forces recently obtained at CERN with the discovery of the W^+ and Z° bosons, as discussed by P. Darriulat (CERN), there is now an increased confidence in the theoretical approach to the unification of all fundamental forces. It should be noted that almost a century has elapsed since Maxwell made the first fundamental step of incorporating electric and magnetic forces into one unified scheme—the theory of electromagnetism. As reviewed by P. Fayet (Paris), there are a number of theoretical models which have been proposed to unify the electro-weak and strong interactions, generally known as Grand Unified Theories (GUTs). At this moment, it still appears difficult to work out definite quantitative predictions, but one quantity which seems to be fairly well estimated is the energy of the particles above which the models should become exact, that is to say, the unification energy at which the forces lose their individuality. This energy turns out to be about 10^{14} GeV, which corresponds to a mass which is about 10^{12} times the mass of the W^+ and Z° bosons. This means, of course, that a direct verification of the GUTs via the production of the particles which mediate the unified force is unthinkable, except in the too distant future. However, in the "hot big-bang" picture, these extremely high energies are reached naturally at the very beginning of the life history of the Universe, when its age was less than about 10^{-35} seconds. After this time, the cooling due to the expansion of the Universe brings the average energy of the particles below 10^{14} GeV.

One of the predictions of GUTs is that the proton should decay with a half-life in the range 10^{31}–10^{33} years, very much greater than the age of the Universe (~ 2 x 10^{10} years). This possibility arises because in the GUTs the quarks, which are the constituents of the baryons, and the leptons are parts of the same picture. As a consequence, the baryonic number need not be conserved any more, as had been assumed in the classical models of elementary particle theory. The results of a number of experiments set up to measure the proton half-life were reviewed by E. Fiorini (Milan). The most stringent result is now being obtained from the Ohio Morton Salt mine experiment which sets a lower limit to the proton half-life of 1.5 x 10^{32} years. This result already enables one to rule out the simplest of the GUT models which predicts that the proton half-life would be at most 10^{31} years.

Because of the non-conservation of the baryonic number, one can work out a scheme which leads in the first 10^{-35} seconds to a baryon asymmetric universe, even if one had started from conditions of perfect symmetry between particles and anti-particles, in this way explaining one of the basic cosmological problems outlined before. Unfortunately, it is not yet possible, within the framework of GUTs, to make a quantitatively precise estimate of the excess of matter over anti-matter.

In a related context, G. Giacomelli (Bologna) reviewed the present status of the search for monopoles, the magnetic counterparts of the electric charge, whose existence is predicted by the GUT's schemes. Since their mass is enormous (~ 10^{15} GeV), they cannot be produced in the laboratory, but of course might have been produced in the very early phases of the "hot big-bang" and now pervade the Universe. In fact, the production might have been so copious that one has to invoke "suppression" schemes to avoid conflict with the upper limit on their present space density.

Another important feature of the more elaborate GUTs is the expectation that neutrinos have non-zero rest mass. Obviously, this immediately raises the possibility that "dark" matter, which may pervade the Universe as previously discussed, is provided by the neutrino sea. In the standard "hot big-bang" model one can compute, in a fairly accurate way, the number density of neutrinos which turns out to be of the same order as the photon density in the 3°K universal radiation field, that is

Tentative Time-table of Council Sessions and Committee Meetings in 1984

April 13	Scientific Technical Committee
May 22	Users Committee
May 23	Finance Committee
June 4–5	Observing Programmes Committee
June 6	Committee of Council, Geneva
June 7	Council, Geneva
October 8	Scientific Technical Committee, Chile
November 13–14	Finance Committee
November 27–28	Observing Programmes Committee
November 28	Committee of Council
November 29–30	Council

All meetings will take place at ESO in Garching unless stated otherwise.