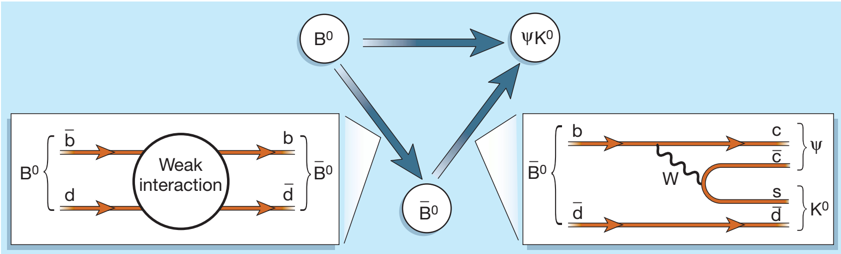

Figure 1 **Decay of a B meson. The B^0 meson (made of bottom and down quarks) can decay into two other mesons, known as ψ and K^0 (made of charm quarks and strange and down quarks respectively). The decay can occur directly, or the B^0 can convert to its antiparticle, the $\bar{B}^0$ meson, through a weak interaction between its constituent quarks (left); the antiparticle can also decay to ψK^0 (right) through another weak interaction involving the W boson. Because there are two pathways to the final state, quantum interference arises between them. The BaBar[2] and Belle[3] experiments exploit this as a means of measuring CP violation.**

In 1972, when the model of weak interactions was still speculation and even quarks (the elementary particles that are the constituents of particles such as the proton and the neutron) were viewed with scepticism, Makoto Kobayashi and Toshihide Maskawa put forward the idea[5] that CP violation originates in the mass mixing of heavy quarks. Quarks were expected to have mass mixing; Cabibbo and others had shown this theoretically[6,7]. At that time, though, only three species of quarks were known (called up, down and strange), and all three had small masses. Kobayashi and Maskawa required more quarks, six in all, to build a theory with intrinsic phase differences in the mixing terms. It was a wild idea. But, wild or not, these extra, heavy quarks (charm, bottom and top) have since turned up in experiments — the sixth, top, quark only in 1995.

If heavy quarks are needed for CP violation, it is logical that the decays of heavy quarks would show much larger CP asymmetries. Bigi, Carter and Sanda[8,9] proposed looking in the decay of a B^0 meson (a particle that contains a heavy bottom, or b, quark together with a light quark) and specifically in its decay to two other mesons, called ψ and K^0. This decay can occur by two different paths (Fig. 1): either the B^0 can convert directly to ψK^0, or it can convert to its antiparticle $\bar{B}^0$, which then turns into ψK^0. In quantum mechanics, when a reaction can occur by two different paths, interference results. In this well-chosen reaction, the relative phase of the interfering terms is precisely the CP-violating phase of the Cabibbo–Kobayashi–Maskawa (CKM) model. If CP violation is fundamentally a large effect, the phase should be large.

Experimentally, measuring this phase is challenging. This particular decay can be observed in only 1 in 100,000 B decays, requiring huge numbers of high-energy collisions and unprecedented accelerator performance. New accelerators were built in Japan and the United States to meet these needs and have been operating for three years. They now hold nearly all the performance records for colliding-beam particle accelerators, and their corresponding detectors, Belle and BaBar, have collected a total of 300 million B decays.

At this summer's International Conference of High Energy Physics in Amsterdam, the BaBar and Belle experimental groups presented the results on the CKM phase that they have derived from these data[2,3]. The two results are precise and consistent. Remarkably, the value of the CKM phase they measure is exactly that needed to explain the magnitude of CP violation seen in the Cronin–Fitch experiment nearly 40 years ago. In the next few years, these measurements of B decay will be sharpened and new measurements from BaBar and Belle, and from the experiments at the Fermilab Tevatron, will come into play.

There is much at stake, for, despite many attempts, no one has been able to use the CKM model of CP violation to create the matter excess of the Universe through Sakharov's mechanism. Only a small asymmetry is needed in the early Universe, as today we have only one leftover proton for 10^9 photons. But simple calculations in the CKM model give a prediction of one proton to 10^{18} photons, and no cosmological model has been found that improves this by more than a few orders of magnitude. The problem is that CP violation in the CKM model requires not only the heavy-quark but also the light-quark masses, and these latter terms are unimportant at the high temperatures of the early Universe[10]. Models of CP violation that involve heavy objects only — for example, models with additional CP-violating phases in the mass mixing of Higgs bosons or other undiscovered particles — can readily account for the observed excess of protons.

Unless the new particles are extremely heavy, their CP effects should also show up in B decays. If these particles are present, the precise B-decay experiments of the next few years should show anomalies: perhaps qualitative differences from the CKM predictions, perhaps 10–20% discrepancies that the CKM model cannot account for. At present, no one knows what the result will be. Later in the decade, millions of top quarks and other

NATURE

100 YEARS AGO

A careful experimental inquiry regarding the nutritive value of alcohol has recently been carried out in the chemical laboratory of Wesleyan University… The main question studied is the value of alcohol as a fuel in the human body and its comparison in this respect with sugar, starch, fats and other nutrients of ordinary food materials. Collaterally, the question of the effect of alcohol upon the proportions of nutrients digested from the food with which it was taken has also been examined. Metabolic experiments on an elaborate scale have been instituted with the view of investigating the problem, and no expense has been spared to obtain complete and accurate results… The results of the inquiry indicate that more than 98 per cent. of the ingested alcohol was oxidised in the body and that the potential energy of the alcohol was transformed into kinetic energy as completely as that of the ordinary nutrients… The conclusion is drawn that so far as the utilisation of the total energy of the diet is concerned, there is a slight advantage in favour of the non-alcoholic diet, especially when the body is subjected to hard muscular exertion, but the difference is so small as to lie almost within the limits of experimental error.

From *Nature* 4 September 1902.

50 YEARS AGO

An investigation into the interests of about 391 people (241 males, 150 females) who are taking science subjects in adult education classes showed that the females were more extreme in their preferences and dislikes than the males… Males were most interested in studying future advances and new discoveries and theories in science and, next to these, medicine, health and the industrial applications of science. Medicine and health were the most popular subjects for females, and almost as popular were pure biology and psychology. Neither males nor females took much interest in aeronautics or in the public direction and use of science; even less interest was shown in the work of scientific institutions and the results of science surveys and commissions. This may indicate that the 'ordinary' man is not fully conscious of the impacts of science on communal life or, perhaps, is little interested in the development of society as distinct from the individual.

From *Nature* 6 September 1952.