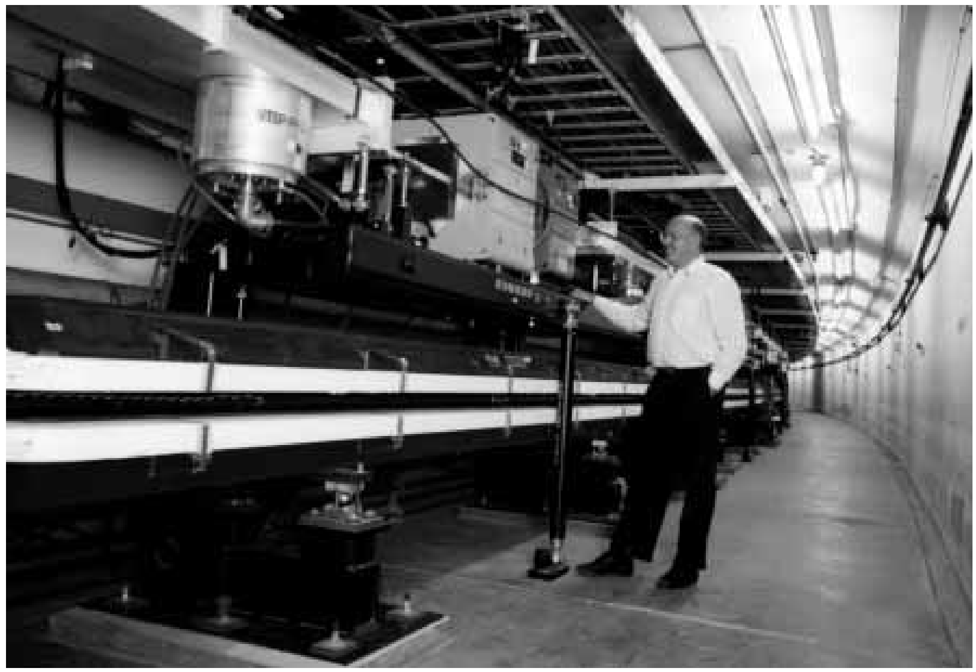
FOREWORD

SLAC's new Director shares his thoughts about the race to understand why the Universe is made of matter.



CONSERVATION LAWS IN PHYSICS represent simplification in Nature. They arise due to underlying symmetries in the mathematical description of our physical world. Thus, violations of expected symmetries have wide-ranging impacts on our perception of Nature. The unequivocal demonstration in 1957 of the violation of mirror symmetry (better known as parity violation) in the weak interactions shook the physics community. What was particularly shocking to purists was the fact that parity violation was pervasive in the weak interactions and that the size of the violation was maximal. Order was restored when physicists realized that parity was simply the wrong symmetry; the weak interactions are symmetrical under the combined operation of charge conjugation and parity, known as CP.

But this tidy picture fell apart in 1964, when Val Fitch, James Cronin, James Christenson, and Rene Turlay observed small, but significant, violations of CP symmetry in the decays of long-lived, neutral *K* mesons. Further experiments demonstrated that these particles decayed ever so slightly less often to electrons than to their antiparticles, positrons—thereby providing a possible link between the phenomenon of CP violation and the asymmetry between matter and antimatter. In 1967 Andrei Sakharov proposed an idea for how our matter-dominated Universe might have emerged from the Big Bang, which produced equal amounts of matter and antimatter. One of the key elements in this theory is the requirement of CP violation. What appears as a tiny violation of CP symmetry in the weak interactions could well be a critical reason why we exist.

While the dominant Standard Model of particle physics incorporates the phenomenon of CP violation, the correctness of this implementation is not experimentally verified. In addition, the Standard Model fails miserably in its ability to predict correctly the observed ratio of protons-to-photons in our Universe. The size of this ratio, a key relic of the Big Bang, is directly related to the "strength" of CP violation, whose role was to transform a matter-antimatter symmetric birth into an ever-so-slightly matter-favored infancy. As the matter-antimatter soup cooled, pairwise annihilations produced the sea of photons recognized today as the cosmic background radiation. Because of the tiny asymmetry, however, some matter was left intact, leading to our proton-dominated Universe. The larger the strength of CP violation, the greater the initial asymmetry and thus the larger the relic proton-to-photon ratio. There exist alternative models of CP violation beyond the Standard Model that predict proton-to-photon ratios in line with observations. It is crucial to make detailed measurements of CP violation that have the capability of challenging all these models and establishing an experimental basis for its origin.

The study of CP violation in the neutral kaon system continues to be fruitful. Recent results from Fermilab and CERN are achieving impressive levels of precision, establishing the evidence for direct CP violation. The Phi Factory in Frascati will soon begin producing data to add to this knowledge. But to challenge the Standard Model in a definitive way requires measurements of the decays of the *K* meson's heavy "brother," the *B* meson. Neutral *B* meson decays offer a broad spectrum of channels whose measurements will directly confront the predictions of the Standard Model. What ten years ago was just a gleam in experimenters' eyes is now becoming reality as facilities capable of producing and studying huge samples of *B* mesons are coming to fruition. The CDF experiment at Fermilab has shown that it is capable of making CP-violation measurements of *B* mesons; along with the D0 experiment, it awaits the first run of the new Main Injector. At DESY, the HERA-B experiment will soon commence data taking. But, the broadest attack on CP-violation will likely come from the two asymmetric *B* factories, one at SLAC and one at KEK. These two facilities have recently begun taking data and should produce their first results within a year. The articles in this issue describe the capabilities of these different approaches to the great challenge of understanding the origin of CP violation.

We are now poised at the onset of what will surely be an important chapter in our understanding of CP violation. The next few years should be exciting indeed.

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